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Journal
of Indian Water Works Association

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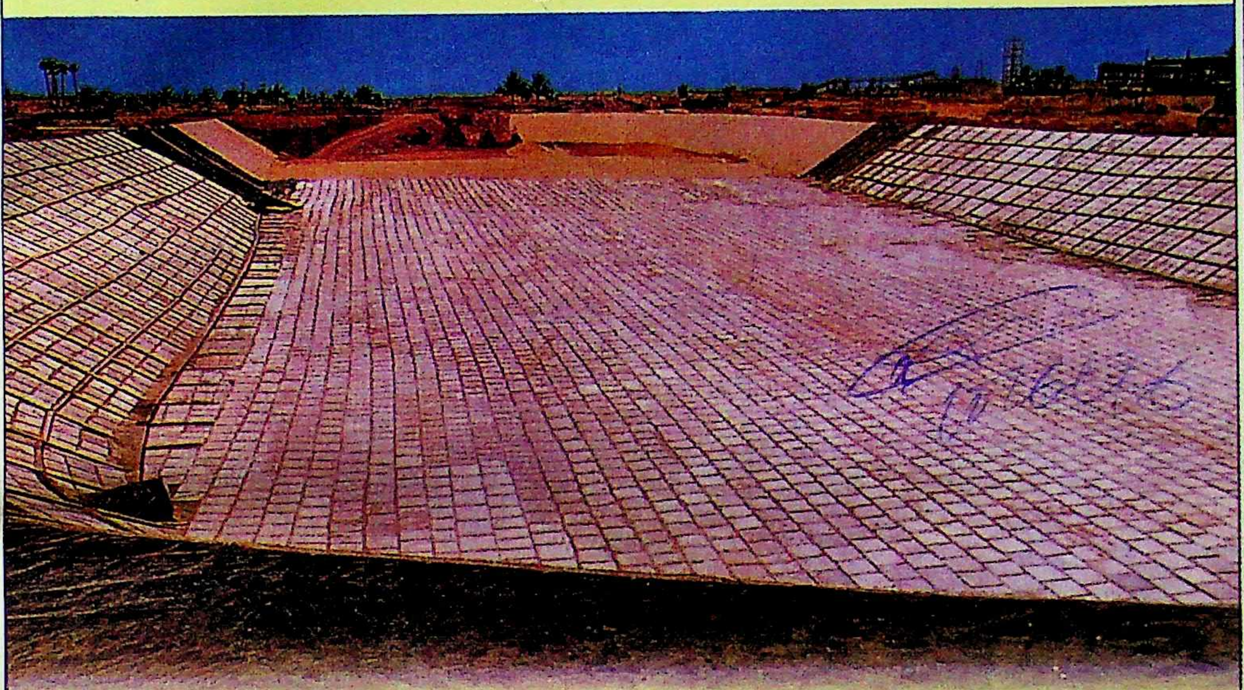

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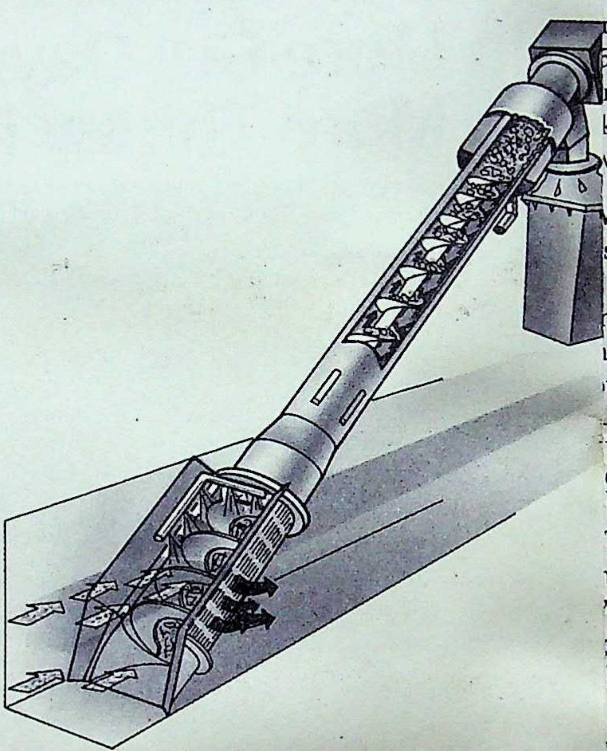

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son, Mumbai, have already done it.** Others
invited to emulate their example. Such a
nsor of article in the journal (through pay-
it of donation) will be duly acknowledged
w the article published.

9th Annual Convention of IWWA

The 29th Annual Convention of IWWA will
ield **at Calcutta from 3rd to 5th January,**
'. The broad theme of the convention is 'Chal-
ges in Water Supply Systems'. More details
being printed in a brochure, which will be
to Members of IWWA and others interested.

ANAND NAVKAL joins the Editorial Board

ri Anand H. Navkal has recently joined the
orial Board of this journal as one of its Hon.
ibers. A brilliant scholar of V.J.T. Institute,
nbai and a Masters Degree Holder in Water
ources Development from University of
kee, Shri Navkal has gathered a long, rich,
varied experience in the design, construction
management of large water projects before
ing from the irrigation department of the
ernment of Maharashtra as secretary (CAD)
year. He has also worked on deputation as
chnical Adviser to Central Water Authority
ie Government of Mauritius for about four
s and is presently advising the Government
Iaharashtra on safety aspects of water re-
ces in the earthquake-prone districts of Latur
smanabad. I am sure, his help and contribu-
to the journal will enhance its prestige and
ty. We welcome Shri Navkal to our Edito-
Board. ❑

IMPORTANT

FOR SUBSCRIBERS TO THE JOURNAL OF IWWA

All the subscribers to the journal of IWWA have been informed through a letter by the Administrative Manager of IWWA as well as through a printed reminder inserted in the January 1996 issue of the journal of IWWA that they should renew their subscription to the journal for the year 1996 immediately if not done so far. The reminder in the journal also contained the subscription renewal form. **It will not be possible for the I.W.W.A. to send copies of the journal from this issue onwards to those subscribers who have not renewed their subscription so far.**

All the subscribers may please note that the Annual Subscription is to be renewed each year in the last week of December for the next calender year. We have an offer for paying the subscription for three years in advance at a discounted rate of Rs. 420/- which eliminates the bother of remembering to renew the subscription every year. Subscribers may please take advantage of this facility.

Congratulations Mr. Unvala ! You have done it again

Mr. S. P. Unvala

A founder member of the Indian Water Works Association, its past president, presently working as its Hon. Director (Admn.) and Hon. Editor Mid-stream, Shri S. P. Unvala will be adding shortly one more feather to his cap. He has been selected for Honorary membership of the American Water Works Association of which he is already a life member. He is to be honoured on 24th of June 1996 at the Toronto Annual Conference of AWWA for his over 30 years of support for AWWA and his outstanding leadership in the world of International Water Supply.

We congratulate Shri Unvala for the honour which is being bestowed upon him and wish that he scales greater heights in his professional career which is devoted to water, the basic necessity — nay, the essence of life.

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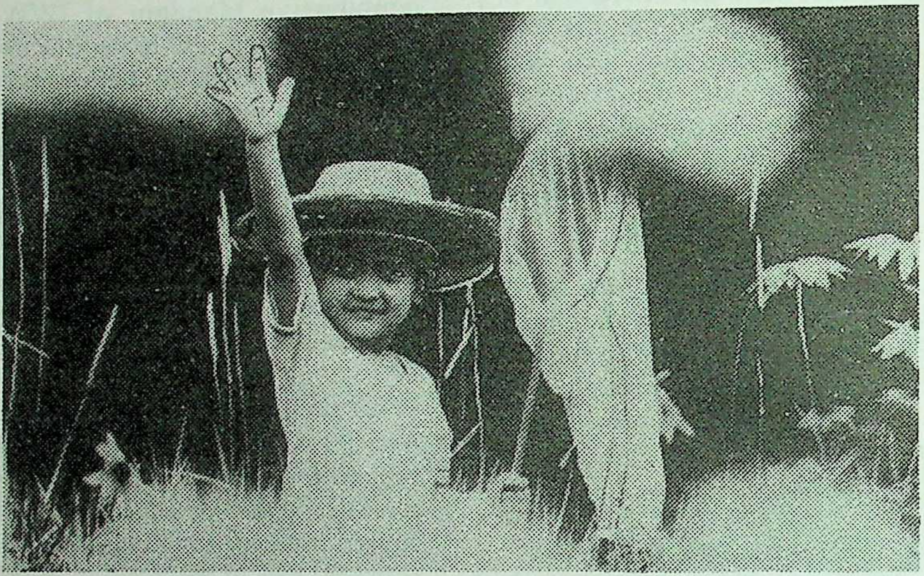

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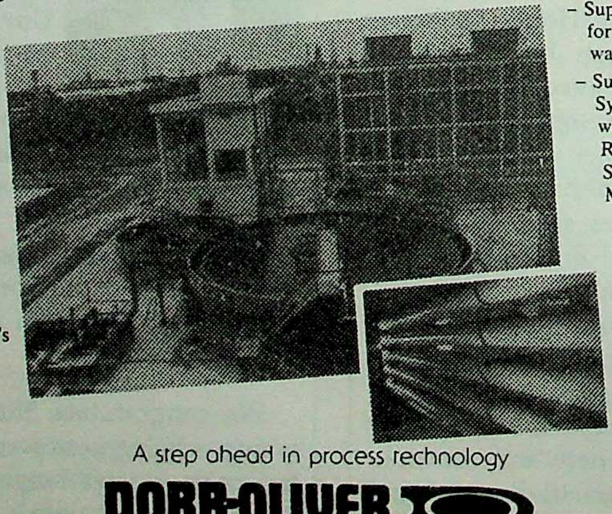

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The views expressed in this journal are not necessarily those of the I.W.W.A.

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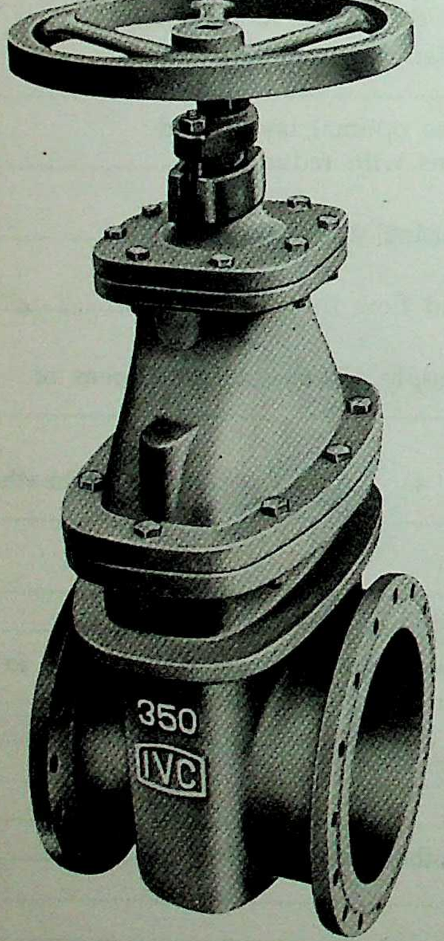

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Editorial

It is a pleasure in presenting to its readers this last quarterly issue of our journal for the year 1996, which contains different topics in the field of water works to which IWWA is now catering to, i.e. irrigation, water supply, treatment and disposal of wastewater etc. It begins with an article on water conservation in agricultural lands which is quite significant now for our country in getting the best out of a good rainfall it has received this year, since we know that irrigation is consuming over 85 per cent of all the water used in our country and it is not that what we get, but it is what we save, we gain.

Water received has to be treated for domestic and other uses. Many innovative techniques are being deployed for making the treatment process simple and economical. This is particularly necessary for plants catering to smaller towns and rural areas. An article about a non-conventional water filtration plant designed and constructed for augmenting the capacity of an existing treatment works in Gujarat state will therefore be quite useful to the field engineers and readers of this journal. The sludges produced in water treatment are also to be treated and then properly disposed of. A small research article on economics of centrifugation of sludges with and without the use of chemicals therefore finds a place in this issue.

Water supply is brought to many towns and cities through one or more of the sources and is also distributed after treatment through one or more distribution service reservoirs. Optimum utilisation of the quantities and heads available at them requires simultaneous solving of some mathematical equations which is quite complicated and time-consuming. A single step simple solution for it has been the topic of one of the papers published in this issue which would be helpful to the water works design engineers in the country. Water quality has to be maintained right upto the consumers' end beginning from the sources. A case study by experienced consulting engineers in this respect has been reported in a paper published in this issue which will be quite interesting to persons working for maintaining water quality in the total system.

IWWA has been giving considerable importance to the different aspects of water supply to rural areas of our country (where lives over 70 per cent of the population). The article in this issue on problems pertaining to water supply for rural areas in the hilly terrains and remedies sought will be quite helpful and guiding to the field engineers working for these areas. IWWA always welcomes experiences of social workers in this respect and a paper regarding it about treatment of water in Chitrakoot region of M.P. has found place in this issue.

Public water supply systems of towns and cities have to be self-supporting and sustainable for which regular inflow of requisite finances from the water consumers is absolutely essential. An article based on the experience gained and emerging recommendations therefrom of a water supply engineer/manager working in U.P. Jal Sansthan are quite revealing, which is published in this issue. Water supply is again a part of integrated environmental projects and an article in this respect written by an experienced field engineer describing the treatment and disposal of waste water produced in a town in U.P. using upflow anaerobic system, contained in this issue will be quite useful to field engineers working in the area of treatment and disposal of waste waters.

The issue as usual carries Short Communications in which the second part of the series on computer application in water supply has been published. Foreign news, forthcoming events, synopses of papers published in other technical journals etc., are also finding their place in the issue making it a comprehensive piece of informative technical literature and I am sure that the readers would like it and they will appreciate the contents and the efforts put in by the members of the editorial board and the reviewers of the papers published who all have helped in correcting, modifying and improving them and to whom I am very much grateful.

Mumbai
1-10-1996

Kshirsagar

S. R. Kshirsagar

Editorial

Indian Water Works Association held its 28th Annual Convention at Jodhpur from 12 to 14th January 1996, which was hosted by its Jodhpur Centre. The common feature of all the conventions is to have besides the address of the newly elected president of the Association, two important lectures by eminent invited speakers. This issue is carrying the full text of those speeches for the benefit of those who could not attend the convention.

In his address the newly elected president Shri R. M. Sagane gave his thoughts on needs of water supply and sewerage sectors which included all aspects such as technical, managerial & financial. He also gave some useful recommendations pertaining to recycling and reuse of water; ground water recharge, community participation, institutional set up etc. Late N. V. Modak Memorial Lecture was delivered by Prof. K. J. Nath, Director, All India Institute of Hygiene and Public Health, Calcutta. After dealing extensively with different types of waterborne and related diseases and their relation with (ill-)sanitation, he described in short, the health problems of Rajasthan state which are due to guinea worms, high dissolved solids & fluorides and nitrates etc. in ground water and the solutions to these. V. Raman Endowment lecture was delivered by Dr. A. S. Firoda, Director, Ground Water Board of Rajasthan State. He gave information about the water quality in different parts of the state and its causes and remedies. All the three lectures are highly informative and thought-provoking and are specially published in this issue for the benefit of the readers.

This issue also carries three more papers from renowned experts. One is on flood management by Dr. Ramanand Yadav and Dr. Pande B. B. Lal which is tracing the history of these in Eastern U.P., their causes and ill effects and suggestions towards prevention. The other is regarding water resources development in Gujarat State by Shri S. K. Gupta which is quite significant now, since we observe Water Resources Day in our country in the month of April. The third is from Shri Chetan Vaidya, a Socio-economist working in water sector giving his experiences about demand for water and willingness to pay by the consumers through an actual survey carried out in some urban areas. He observes that people are willing to pay where there is good service and water supply schemes can be made self-supporting financially by improving and maintaining the service level.

We also have in this issue, other usual features such as short communications, synopses of papers published in other technical journals, book reviews etc. and a report in brief about the 28th Annual Convention held at Jodhpur. We are also starting from this issue, a feature to give information about computer programmes available for use in water sector and the credit is to Shri A. R. Altekar, a silent studious member of the Editorial Board. I am glad to inform our readers that Shri Anand H. Navkal, a water resources engineer who has retired recently as the secretary (CAD) to Irrigation Department, Government of Maharashtra, has joined the Editorial Board. This has obviously enhanced the Board's capability in dealing with aspects of water. The scope of the topics to be covered in this journal is thus widening and is now encompassing the entire gamut of Water Environment. The Editorial Board has accepted this challenge and will stand to the test of time in satisfying the needs of its readers and in educating water sector personnel for improving their knowledge and career prospects.

Mumbai,
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Presidential Address at the 28th Annual Convention of IWWA on January 12th, 1996 at Jodhpur

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Water Supply and Sewerage — Sectoral Needs

R. M. Sagane*

Honourable Chief Guest, Past President Shri Raguvanshi, Members of the IWWA, foreign and national delegates, ladies and gentlemen,

It's a matter of great pride for me to be the President IWWA for 1996-97, since I feel, this is going to give me a chance to interact with the elites of water and sewage industry, the scientists, the social workers and the thinkers in this sector, specially at a time when in my state of Maharashtra the State Govt. has accorded top priority to drinking water, has published a white paper, and established a separate ministry of water supply and sewerage and also a water authority in the Government.

At the outset, I would like to draw attention of the learned audience to the fact that all the while, more stress is laid on drinking water supply than on sewerage. There are reasons for such disparity in priorities; basic reason being, the per capita water supply itself being inadequate and less than 140 to 200 LPCD (minimum required for a sewerage system to function), thinking about underground drainage schemes is out of question in majority of towns except for major towns and metropolis. Secondly, the resource crunch does not allow us to do justice to the sector of sewage disposal. It is not denied that to protect the valuable drinking water from contamination, proper sewage collection, its treatment and hygienic disposal is the most effective and result oriented need. It is needless to say that if sewage is eliminated from the scene, bacteriological contamination would end and so would disappear the water borne diseases. As such, our aim has been to accord priority to provision of safe drinking water. But let us not forget that in addition to "water for all by 2000 AD" and these two aims need to be synchronised by the planners of health programme at policy formulation as well as operational levels, which desires that the health extension programme too should contain efforts to bring about improvements in the water supply and consumption and sanitation habits of public. Efforts are therefore being made to eliminate the method of head load system of carriage and disposal of night soil, (which is almost abolished now) and to promote low cost sanitation schemes like twin pit latrines all over India. Besides, the National River Cleaning Action Plan is being extended in the States to take care of proper sewage disposal so as to save river and environmental pollution.

It is unfortunate that drinking water supply or underground drainage schemes do not have an indicator like cost benefit ratio (as in irrigation projects) or valuation of results in financial term; but surely the efficacy of the schemes can be evaluated in terms of saving in loss of man hours due to water borne diseases and an overall improvement in health status, productivity, and out-turn etc. It is a matter of great satisfaction that Governments, both at national and State Levels have understood and appreciated the value of water in above manner and have accorded highest priority to drinking water, both in respect of allocations as well as share in total water usage.

National and Global Response and Resulting Policies and Goals and International Drinking Water Supply and Sanitation Decade.

Year 1948 :

Government of India realised the development needs of our sector in 1948 and set up a high level committee namely "Environmental Hygiene Committee". This committee, for the first time, highlighted the need for a national level arrangement for formulation of sector development programme.

Year 1954 :

As a sequel to above, the National Water Supply and Sanitation programme was launched in 1954 and CPHEEO was set up as the nodal agency. This helped to get a separate plan allocation for this sector, expedited the setting up of separate PH Engineering Departments/Water Supply Boards at State level, recognition to the Public Health Engg. as a specialised discipline at the post graduate level of inservice training to personnel engaged in the sector.

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* Member Secretary, Maharashtra Water Supply & Sewerage Board, Mumbai, Maharashtra.

From 1951 to 1981 (the plan period), the allocations on water supply and sanitation sector increased 2.5 times. Population coverage in urban and Rural Water Supply reached 72% and 31% respectively and that of Urban Sanitation services to 25%. Thus, high priority to water supply and sanitation sector was given.

Then came the International Drinking Water Supply and Sanitation Decade 1981-1991, the ideals of which were provision of safe water supply in adequate measure to all and hygienic disposal. Govt. of India accepted this challenge.

The success of this decade programme is as under:

Sector Category	Status in 1981	Coverage by 1990
Urban Water Supply	72%	90%✎
Rural Water Supply*	31%	100%
Sanitation		50%◇

✎ target was reset from 100% to 90% in mid decade.

◇ target was reset from 80% to 50% evaluation in 1986.

* Piped water supply to 30% of population and spot source water supply to 70% population.

Added impetus was received owing to inclusion of drinking water supply in the 20 point programme launched by Prime Minister Late Smt. Indira Gandhi in year 1980.

Govt. of India has launched Technology Mission on drinking water in villages and related management, with the aim of coverage of 227000 residual problem villages and improving the performance and cost effectiveness of ongoing rural water supply programmes to ensure availability of adequate quantity of safe drinking water on sustainable basis. It has an integrated approach.

Government of India is also assisting the State Governments for Supply Schemes to small and medium towns, with 1991 population upto 20000 souls, by way of 50% GIA.

Water availability — Present Scenario:

95% of water on the surface of the earth is either saline or in the form of polar ice-caps, hence not available. Out of remaining 5%, about 4.98% is underground — largely in deep aquifers, so only 0.02% is held in fresh water lakes and flowing streams — which is the readily available part for various water uses.

In our country, only 30% of the available surface water and 70% of underground water is utilisable. However, this available water is also experiening symptoms of strain in terms of depletion and pollution due to unregulated and multiple uses of river stretches and use of pesticides and fertilisers in Agriculture. The problem has therefore been getting more and more difficult in these days of modernisation and technological and scientific advent and the country is facing acute shortage of an easily and economically treatable raw water, for drinking water supply schemes.

To add to this impact of modern age, nature's vagaries have made the situation very unpredictable, hence difficult. In the recent decades, the nature's cycle has undergone surprising changes. Although the total water remains same, the seasons of rainfall, its distribution over areas, intensity and duration have all changed in an irregular pattern. As a result, the so far assured sources i.e. the storage reservoirs, are not filling up fully and are getting empty at the beginning of the hot season. Rivers go dry from the month of February itself. As a result of this, we have started over exploiting the underground water without any care to recharge it. This way, both surface and the underground waters have become scanty. Very distant sources are required to be considered for new/augmentation schemes to provide minimum level of service. Large number of temporary/emergency water supply schemes are required to be taken up, which consume large chunk of funds — without any permanent advantage.

Sources for Urban Water Supply Schemes, India

	Sources of Supply	
	Cities Class-I	Urban Towns Class-II
1. Surface Sources	73%	50%
2. Ground Water Source	23%	43%
3. Combined Sources	4%	7%

Already low supply of water in the towns is further affected by lack of understanding by public about the tremendous efforts and cost involved to maintain minimum service level in summer and about the need to check wastages in the system and theft of water. Towns are affected since there is a large scale urbanisation ('91 level was 26% which has risen to 35% in 23 metropolitan cities and class I towns and is likely to go to 45% by end of the century), industrial demand is large and standard of living has increased the domestic water consumption. In villages also, situation is same since most of the schemes are based on underground water and the ground water table goes down rapidly with onset of summer.

Thus, the time is ripe to educate the community that water is scarce, has a value and needs to be conserved through proper management.

From the foregoing paras, it is clear that water is getting scarce both in quantity and quality and so, its exploitation, distribution and use has to be well managed and balanced. However, when we observe in field, the position in above regard, we realise that the task is not easy since a number of factors are involved in accomplishment of a successful, economic, easy to operate, sustainable and self supporting system of urban as well as rural water supply.

Urban water supply and sanitation schemes differ from the Rural Water Supply Schemes. Urban Water Supply schemes are fewer in number but higher in cost and in the water requirement than Rural Water Supply Schemes; as such, problems are more serious in Urban Sector.

I would try to highlight these problematic areas and the need of reforms required there, so that the sector sails well, giving expected benefit to the masses.

1. **Water Allocation :**

It is a welcome step that Govt. of India as well as all State Governments have accorded top most priority to drinking water while reserving water in the Irrigation Projects, Rivers etc.

As in Maharashtra State, it is advised that a water authority be set up in every state to decide allocation of water for different usages (like Irrigation, Industry, Drinking etc.)

2. **Financing of urban WSS — for a viable water tariff :**

(a) *Govt. Grants :*

Schemes are getting very costly day by day, and the burden on the local bodies is very high. In case popular contribution is insisted, many councils cannot pay it even in instalments, therefore the execution delays and there is a time as well as cost over-run.

It needs to be thought of if the water supply schemes should be aided 100% by Govt. since water supply is the responsibility of Government. Such policy shall have following advantages and disadvantages.

Advantages :

(i) Execution can start immediately after administrative approval, cutting down escalation costs in future.

(ii) Since repayment of principal amount and interest on loans have an effect on cost of water/water tariff, fully GIA schemes would mean lower tariff hence better recovery, and O&M will also be self supporting.

Disadvantages :

Government budget shall be burdened more and probably, without any external assistance, there may not be adequate allocations available in the State Plan.

(b) *Loans :*

Presently, LIC/GIC/Nationalised banks grant loans, but Municipal Councils find the repayment difficult. Therefore, in such cases, LIC should increase moratorium to 5 years when the demand for water is not developed and revenue is meagre or alternatively the Govt. can itself arrange for soft and long term loans.

3. **Beneficiaries' role :**

Since the Water Supply Schemes are to be handed over to local bodies for maintenance and operation which is the most important step to assure a sustainable scheme with adequacy and reliability of supply, there is a need for preparation, prior to taking up any scheme :

(1) To get required staff sanctioned from Govt. well in advance and train them either during execution or during trials.

(2) To bear the cost of maintenance and also any subsidy (if required to pass on to public while fixing water charges). The MC should start setting aside some amount right from the year of inception of scheme and keep it in Fixed Deposit. This would cater to the requirement of MC for O & M to some extent.

4. **Technical Requirements :**

(a) ***Preparation of Projects :***

The projects should be prepared with adequate detailed survey and levels with selection of a pollution free source by experts, proper anticipation of requirement of acquisition of land — Govt./forest/Private, various permissions like water extraction, road and railway crossing etc.

Escalation, yearwise, for period of construction should be provided for in the estimates. Besides, cost of trial run for period of a few months should also be included. This will avoid faulty schemes and time and cost over runs.

It is also advisable to include an abstract of material required for the scheme, a proforma for taking over document and O & M instructions to help Municipal Council in maintenance and operation of WSS.

Undue economy needs to be avoided, specially in important and large schemes. Only ISI mark material/appurtenances should be used. Third party inspection of material shall avoid quality problems.

(b) *Execution :*

Success of Scheme depends upon the skill and perfection in execution; as such, following care is essential.

(i) *Source :*

Should be Pollution free, adequately guaged to meet the demand, supplemented by recharging structures like underground bandharas, stop dams/weirs, etc.

Storage capacity of a bandhara, weir, dam should be 365 days and not 240, in view of erratic rainy seasons these days.

For medium and large population, mere dug well (i.e. ground water as source) should not be proposed. Surface water sources should be adopted for long term planning.

Unconventional sources should be tried in case of hard core habitations.

(ii) *Conveying Mains :*

Care in ensuring adequate depth of trenches for pipelines so as to leave a cover of about 1 m above top of pipe; straight laying of pipes, a firm support to pipes and anchorage; strengthening of pipeline on curves, provision of expansion joints and adequate air valves above ground etc. are necessary to protect the pipeline from damages. It is necessary to choose the type of pipes to be used based on type of soil and ground water table etc. rather than merely on pressure rating conditions. Of recent manufacture of Ductile Iron Pipes is started in India and its use is expected to eliminate problems in Pipelines considerably.

(iii) *RCC structures :*

Water retaining structures require careful design and a well monitored construction; as such, care in designing the mix and in curing during construction is vital.

There have been instances of collapse of centering and form work of elevated tanks hence designing of centering should be insisted.

(iv) *Computerisation and Use of Hightech instruments :*

Use of computers in many fields in the sector of water supply and sanitation is being made these days and right from office data keeping to billing etc. computers are doing excellent service. Our endeavour should be to link all the field offices with central office (cost being the only constraint). However, in respect of instrumentation and automation, I feel, majority of our Water Supply Schemes do not deserve high tech instrumentation and automation for obvious reasons of poor capability of O & M staff. It can however be tried for metropolis or well managed, and technically as well as financially well equipped towns.

It should be our endeavour also to use latest techniques, which prove comparatively economical in long run, in all unit processes and in the field. To cite a few examples, use of SBR rubber gaskets for jointing of C.I./D.I. Pipes and S.B.R. rings in case of AC pipes would prove beneficial due to the long life and freedom from termite attacks. Use of D.I. Pipes which are in between C.I. and Mild Steel pipes in cost but as good as M.S. in properties would ease problems in maintenance.

Use of prefabricated structures would do away with poor quality of construction in the interior.

Use of chemicals like catfloc, in replacement of alum, has been found to be more effective and cheaper.

Use of gaseous chlorine be insisted instead of TCL Powder since TCL is very unstable in chlorine contents and many instances are observed when inadequate chlorination has occurred owing to poor control on testing of available chlorine in TCL.

Use of automatic robot with timer arrangement for starting and stopping of pumps also helps in proper maintenance.

Operation and Maintenance :

Even well planned and executed schemes can fail to give proper service if not maintained correctly (both preventive as well as corrective maintenance).

Normally, the local bodies are not willing to take over the schemes for O & M, to levy proper tariff, to revise it annually and to actually recover it. Similarly, they do not have trained staff and adequate finances to maintain the scheme. It is therefore essential that the schemes designed are easy to construct and operate and as far as possible, gravity fed i.e. without much use of electric energy, to the extent possible.

It is essential that O & M of the scheme should be in the hands of skilled staff. For this, staff should be trained or O & M contract be fixed by the council. I feel the O & M cell in the MC, (Municipal Councils) should be properly trained in this respect.

In case O & M is entrusted to the executing agency, the MC and the agency should open a joint account in the bank, where the consumers would pay the water bill and amount towards recovery of cost of O & M can be withdrawn by the agency spending it. In any case, a supervisory body (PHED or Board) is essential to supervise O & M.

Local body should be apprised of the tariff structure calculations, about subsidising the cost of water etc. The District Collector must insist on MC to make a provision for O & M in its annual budget for his passing it.

Depreciation must be provided for and credited in Bank Account annually and used in future for repairs and replacements needed.

Following stipulations would help in creating cost economic and sustainable assets of water supply and sewerage schemes. National conference on Urban water supply and sanitation policy, held in March 1993, has also recommended these —

1. **Water Conservation, Ground Water Recharge, Recycling and Reuse :**

Water, having become a scarce commodity, requires replenishment not only through nature but also through human efforts. Industrial and commercial establishments must be persuaded to adopt reuse of treated sewage and recycle their treated trade effluents, to the maximum extent possible, to cut down their fresh water demand. Incentives could be considered in the form of rebate on water cess charged to them. Use of treated sewage effluent can be tried for non potable purposes like horticulture, flushing of sewers and toilets etc. with due study.

Conservation is the demand of time. Hence, adopting the well established methods, conservation should be tried at source, in treatment unit and at consumers' end. It can also be effected by levying varying slab rates i.e. higher charge for higher consumption.

In Maharashtra, the Government, in the white paper published on water supply recently, has accepted the idea of drawal of water from Dam to the headworks source through closed conduit. This would save considerable water from evaporating and seeping, when let out in river to reach the head works, far off from the Dam. This would cost more initially but would conserve a large quantity of water so scarce. This would thus mean "Water saved — water produced".

Ground water recharge is possible through special techniques developed by GSDA (Ground Water Survey & Development Agencies). Even small anicuts, underground bandharas or impermeable dykes taken at source, effect good recharging.

2. **Community participation and women's and Children's Education :**

Water Supply and sewerage are the fields where community involvement is vital for sustenance and smooth running of the scheme. For maintaining transparency, community should be involved in evolving the required pattern of scheme and locations of structures etc.

City level consumer forums and voluntary agencies may be encouraged to keep a vigil on the water resources to prevent contamination and also on the distribution system to detect and report leakages, pilferages etc.

Women are the sufferers of water scarcity since they have to carry water on head load. Their involvement would be worth and spontaneous owing to their interest in drinking water. Externally aided schemes have women's inclusion in the village level body.

Children are the most important factor of any society which, if educated correctly, would bring sure results in future as citizens. It is unfortunate that present system of education has not adequately considered water supply, sanitation, personal hygiene and communicable diseases as part of lessons in the text books, at appropriate levels. "Charity begins at home" hence all good habits, and harnessing of knowledge and health awareness is best absorbed right at young age.

3. Human Resource Development and Training:

Each organisation at the state/local body level should be encouraged to have its own training plan and adequate infrastructural facilities commensurate with the work plan, with special emphasis on skill upgradation of the personnel responsible for O & M.

Human Resource Development programme must endeavor to enhance user sensitivity on the part of O & M staff and increase public awareness, which will promote NGO and consumer participation with respect to protection of assets and improve service delivery.

In my opinion, the training needs to be more practical oriented. There is an immense need of training the grass root level workers, since their skill decides success of the scheme. One step ahead is necessary and that is to train the contractors doing the work alongwith their fitters, supervisors etc. The field engineers should also try to impart practical training to the contractors, their workers as well as their junior staff, as per the need for the specific job.

4. Privatisation:

It is a recognised fact that in our field, the chances of success of privatisation are only in O & M of schemes, hence such privatisation could be introduced for new installations initially and extended gradually to the others.

However, privatisation in respect of complete scheme on BOT or BOLT basis does not seem feasible, especially in new schemes since, without cross subsidy the financial working is unviable and no private party would be interested in it without minimum returns.

5. Institutional Setup:

It is also important to think about the institutional set up at state level for the organisation for implementation of water supply and sewerage programme.

States like Maharashtra, Gujarat, Karnataka (Urban), Andhra Pradesh (Urban), Tamilnadu for Madras City, Assam for Urban etc. have water supply and sewerage boards as implementing agencies. Maharashtra has such board since 1977. It is necessary to decide, based on study, the efficacy of a system either Govt. or board to decide the best set up. Govt. of India has set up a committee which is entrusted to study the relative strengths and weaknesses of PHEDs, autonomous boards etc. responsible for Rural Water Supply. The Committee is expected to submit its recommendations to Govt. of India shortly. I too have a mind to take up this issue at the forum of IWWA and recommend to the State Govt. accordingly, so that there is a uniform pattern throughout the country.

IWWA, being a national body needs to take up such policy issues with the State Governments. This would expand the sphere of its activities and would yield fruitful results for a smooth and result oriented work in the sector.

Besides above, I find the following areas where IWWA can pursue with Govt. of India/State Govt. in removing the difficulties faced by implementing agencies.

(a) Forest laws are very stringent and have no scope for priority to water supply and sewerage schemes. Govt. of India needs to be approached by IWWA, through a resolution and also through persuasion to liberalise the law for water supply and sewerage schemes in grant of land and permission to lay pipelines in not only "C" class forest but also reserved forest lands.

(b) Activities of water supply and sewerage should be treated at par with agriculture. This would avoid heavy compensation in acquisition of land where non agriculture rates are levied.

(c) Dual system of water supply, i.e. potable water for drinking purposes and raw or recycled water for non domestic and industrial purposes, should be implemented. Of course the economics for dual pipelines shall have to be viable; but even some extra expenditure on these would save precious potable water. To cite an example, railways should adopt this system, since washing of railway bogies and engines by potable municipal water is a sheer waste.

(d) IWWA can take a lead in recommending to the Govt. to adopt newer concept in design and use of material. Just as system of unlined canals in the past has changed to lined canals today, even with increased cost, similarly mere economy should not be the criterion for using stronger material like CI/DI/MS pipes for trouble-free service.

It is my sincere appeal to everyone in the audience and specially to environmental engineers in the field to share their knowledge and experience in tackling the practical problems in the sector and educate the new generation, through a forum like IWWA.

Last but not the least is to request all the States to try for a 100% membership from the engineers and association from the state so that this august body gets strength organisationally and financially.

Thank you.

Attention Field Engineers

Indian Water Works Association is publishing every quarter its journal for dissemination of information and work experience to the water works professionals and persons interested in this subject on all matters pertaining to water supply & waste-water treatment and disposal systems. We do receive good articles from persons working in the teaching and research institutes, for publishing in our journal.

However, the Association very much wants to publish field experiences for which I appeal to all the field engineers to write suitable articles narrating their experiences about works designed/constructed/operated and maintained by them.

This would help the fellow engineers and others in directly utilising the information published in the articles.

— Editor

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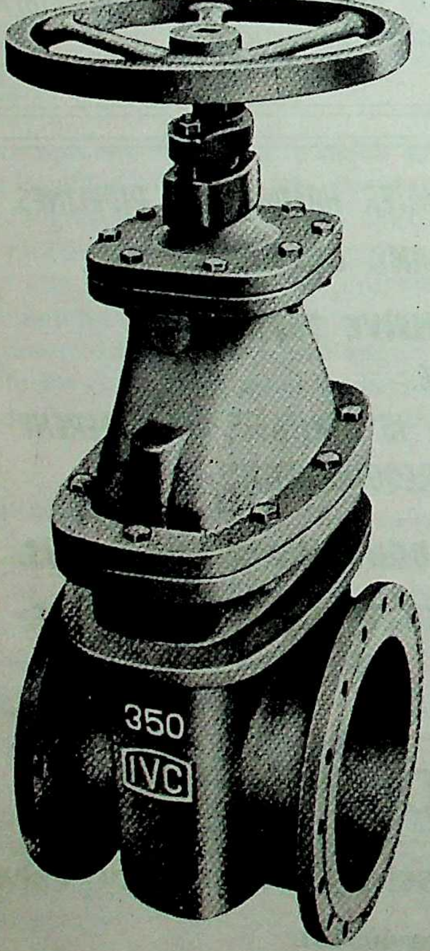

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N. V. Modak Memorial Lecture delivered at the 28th Annual Convention of IWWA on 12th January, 1996, at Jodhpur (Rajasthan)

Water, sanitation and health with special reference to the water related health problems of Rajasthan

Prof. K. J. Nath*

1. Introduction :

Ever since the creation of mankind, air, land and water, the three basic components of man's natural physical environment, have nursed and nourished him for his growth and development. During the last century or so, there has been a perceptible deterioration in the quality of our environment. Any such unfavourable alteration of our surroundings is described as 'Environmental Pollution' which occurs mainly due to infringement from agriculture, human settlements, industries and a host of other anthropogenic activities.

Water and Sanitation related diseases have been found to remain the single most important cause of mortality and morbidity. So far, health benefits have not been commensurate with the investments made in the Community Water Supply and Sanitation Sector. The recent epidemics of water and excreta related diseases and their continued endemicity have brought this issue into sharp focus.

2. Water & Excreta Related Diseases :

A water related disease is one that is in some gross way related to water in the environment or to impurities within water. Water related diseases may be divided into those caused by a biological agent of disease (a pathogen) and those caused by some chemical substances in water. The first group may be called the water related infections and may include some of the greatest causes of disease and death in the developing countries (for instance diarrhoeal diseases and malaria). The second group includes chemistry related diseases such as, fluorosis (linked to high fluoride levels in drinking water) and infantile methemoglobinemia (related to high nitrate levels in drinking water). The latter groups are overwhelmingly overshadowed by the water related infections in the developing countries, but some of them are slowly gaining importance in India, particularly due to industrial development and large-scale pollution of surface as well as ground water. The recent Arsenic contamination of ground water in West Bengal, affecting large number of people, is a case in point. The water related infections are so described because their transmission, or the prevention of their transmission, depends in part upon water (see Table 1 on next page). There are four transmission routes that are *water related*. The four routes are :

2.1 *Water-borne route :*

Truly water-borne transmission occurs when the pathogen is in water that is drunk by a person or animal that may then become infected. Potentially water-borne diseases include the classical infections notably cholera and typhoid, but also include a wide range of other diseases, such as infectious hepatitis, and some diarrhoeas and dysenteries. It must be noted that all water-borne diseases can also be transmitted by any route that permits fecal material to pass into the mouth. The common water borne diseases in India are :

Viral	Bacterial	Protozoan	Helminthic
Polio	Typhoid	Amoeba	Roundworm
Inf. Hepatitis	Shigella (Dysentery)	Giardia	Threadworm
Rotaviral Diarrhoea	Cholera		
	Yersinia		
	Campylobacter		

2.2 *Water-washed route :*

There are many infections of the intestinal tract and of the skin that, especially in the tropics, may be significantly reduced following improvements in the domestic and personal hygiene. These improvements in hygiene often depend upon increased availability of water and their use for hygienic purposes. They may therefore, be dRotaviralescribed as water-washed diseases and they depend on the quantity of water used, rather than its quality. The relevance of water to these diseases is that it is an aid to hygiene and cleanliness, and its quality is relatively unimportant for this purpose.

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TABLE 1

Environmental Classification of Water-Related Infections

Category	Infection	Pathogenic Agent
1. **Faecal-Oral** (Water-borne or water-washed)	Diarrhoeas and dysenteries	P
	Amoebic dysentery	P
	Balantidiasis	B
	Campylobacter enteritis	B
	Cholera	B
	E. coli diarrhoea	B
	Giardiasis	P
	Rotavirus diarrhoea	V
	Salmonellosis	B
	Shigellosis (bacillary dysentery)	B
	Yersiniosis	B
	Enteric fevers	
	Typhoid	B
	Paratyphoid	B
	Poliomyelitis	V
	Hepatitis A	V
	Leptospirosis	S
	Ascariasis	H
	Trichuriasis	H
2. **Water-washed**		
Skin and Eye infections	Infectious skin diseases	M
	Infectious eye diseases	M
Other	Louse-horne typhus	R
	Louse-borne relapsing fever	S
3. **Water-based**		
Penetrating skin	Schistosomiasis	H
Ingested	Guinea worm	H
	Clonorchiasis	H
	Diphyllobothriasis	H
	Fasciolopsiasis	H
	Paragonimiasis	H
	Others	H
4. **Water-related Insect Vector**		
Biting near water	Sleeping sickness	P
	Filariasis	H
	Malaria	P
	River Blindness	H
	Mosquito-borne viruses	
	Yellow fever	V
	Dengue	V
	Others	V

Note: B = Bacteria; P = Protozoan; S = Spirochete; M = Miscellaneous; H = Helminth; R = Rickettsia; V = Virus.

The prevalent type of water-washed infection is that of the skin or eyes. Bacterial skin sepsis, scabies, and fungal infections of the skin are also common and may lead to blindness.

2.3 *Water-based route :*

A water-based disease is one in which the pathogen spends a part of its life-cycle in a water snail or other aquatic animal. All these diseases are due to infection by parasitic worms (helminths) which depend on aquatic intermediate hosts to complete their life-cycles. Of particular importance in India is guinea worm infection. Guinea worm or *Dracunculus medinensis* requires an aquatic intermediate host, and reinfection in man is always and only water-borne. Female worms mature in the deep tissues and then migrate to lie subcutaneously in a limb. Numerous larvae develop within the body of the female which induces a blister in the

TABLE 2

Water and Sanitation Related Infections and their Control

Infections	Importance of Alternative Control Measures							
	Water Quality	Water Availability	Excreta Disposal	Excreta Treatment	Personal & Domestic Cleanliness	Drainage and Sludge Disposal	Food Hygiene	Public Health Importance
Diarrhoeal diseases and enteric fevers								
Viral agents	2	2	1	1	2	0	1	3
Bacterial agents	3	3	2	1	3	0	3	3
Protozoal agents	1	3	2	1	3	0	2	2
Poliomyelitis & Hepatitis A	1	3	2	1	3	0	1	3
Worms with no intermediate host								
Ascaris & Trichuris	0	1	3	2	1	1	2	2
Hookworms	0	1	3	2	1	0	1	3
Beef & Pork tapeworms	0	0	3	3	0	0	3	2
Worms with intermediate aquatic stages								
Schistosomiasis : Intermediate Host — Snail	1	1	3	2	1	0	0	3
Guinea worm : Intermediate Host — Cyclops	3	0	0	0	0	0	0	2
Skin, eye, & louse-borne infections	0	3	0	0	3	0	0	2
Infections spread by water-related insects	0	3	0	0	3	0	0	2
Malaria	0	0	0	0	0	1	0	3
Yellow fever & dengue	0	0	0	0	0	1	0	3
Bancroftian filariasis	0	0	3	0	0	3	0	3

Note : 0 = No importance; 1 = Little importance; 2 = Moderate importance; 3 = Great importance.

TABLE 3

Inorganic Chemicals Causing Water-Related Diseases

Inorganic contaminant	Major source	Sphere most affected	Primary health effects
Arsenic	— Oresmelting, refining — Pesticides	— Air, water	— Arsenic poisoning (gastrointestinal disorders, lower limb paralysis)
Cadmium	— Electroplaters, battery manufactures	— Air, food, water	— Cadmium fumes, joint pain, lung, kidney disease — Possibly carcinogenic, teratogenic
Lead	— Leaded gasoline, batteries — Solder, radiation shielding	— Air, food, water	— Impairs nervous system, red blood cell synthesis — Depends on exposure
Mercury	— Inorganic form Electrical goods, Chloralkali industry — Organic form Slimicides, Fungicides	— Water, food	— Inorganic: disorders of central nervous system, possible psychoses — Organic: numbness, impaired speech, paralysis, deformity, death
Nitrates Nitrites	— Nitrates, agricultural runoff Nitrites, meat preservatives	— Food, water	— Nitrates + amines (in body) yield carcinogenic nitrosamines Nitrates can cause methomoglobinemia in infants

skin, which breaks down. The female exposes her prolapsed uterus there and the larvae are discharged whenever water is sensed by the worm. The life-cycle continues if these larvae reach water containing copepods Cyclops, which eat the larvae. Development to the third stage larvae takes place in the body of the Cyclop and these are infective to human if ingested. Guinea worm is a unique water related infection in that it can be eradicated solely by simple improvement in community water supply. Measures that prevent larvae entering wells and other water sources (e.g. slow sand filtration) will eliminate Guinea worm.

2.4 *Insect vector route:*

The fourth route is via insects that either breed in water or bite near water. Malaria, yellow fever, dengue and onchocerciasis (river blindness), for example, are transmitted by insects that breed in water whereas West African trypanosomiasis (Gambian sleeping sickness) is transmitted by the riverine tsetse fly (Glossina spp.) which bites near water.

2.5 *An excreta-related infection* is one related to human excreta (meaning urine and feces). However, water and excreta-related infections usually have similar epidemiological features and are tabulated in a way that highlights their amenability to prevention through interventions in water supply, excreta disposal, or hygienic behaviour (Table 2).

All excreta related infections are usually transmitted be feco-oral route and have been described under water borne diseases. Two notable exceptions in India are hookworm and tapeworm.

The eggs of the hookworms after being excavated in feces develop in warm, moist soil. After one week or more, infective larvae are formed that cause reinfection by penetrating the unbroken skin, usually of the foot.

2.6 *Chemicals Causing Water Related Diseases (Table 3):*

Arsenic:

The sources of Arsenic pollution in water are generally industrial wastes, contaminating water bodies, either directly or by leaching through soil and also some agricultural insecticides. Though rare, natural arsenic pollution can occur in ground water from arseniferous belts in specific geomorphological conditions, as has been found in some areas of West Bengal. The symptoms of chronic arsenic poisoning include various types of dermatological lesions, muscular weakness, paralysis of lower limbs, etc. Arsenic is a potential carcinogen and skin and lung cancer can occur after prolonged exposure.

Mercury:

Mercury poisoning can occur through food and water. The source of pollution is almost exclusively industrial waste. It must be noted however, that chronic mercury poisoning is less often water borne. Industrial wastes contaminate water bodies and is taken up by phyto and zooplanktons. These are then biomagnified in fish and other sea foods eaten by man. In organic mercury poisoning various types of neural damages occur ranging from numbness, speech impairment to paralysis and death. With inorganic mercury poisoning renal damages can occur.

Nitrates:

Increase in nitrate levels in surface and groundwater is primarily due to agricultural fertilisers and manure, animal dung and other sources of nitrogenous materials in the environment. Human body is capable of reducing nitrates to nitrites in the digestive system. There are two distinct threats to human health from nitrites. First, nitrites can oxidise the haemoglobin to methemoglobin, which is incapable of transporting oxygen in the blood stream. This illness, known as methemoglobinemia or blue baby disease, is especially harmful to infants since they are particularly susceptible to asphyxiation by methemoglobinemia. Secondly, nitrites can combine with various amines in the gastrointestinal tract to form nitrosamines (particularly in low acidity conditions) some of which are carcinogenic.

Fluoride:

Fluoride occurs naturally in water. Though most waters contain below 1 mg per litre of fluoride, there are areas that are rich in fluoride containing minerals, where fluoride content of water can be very high. There is good evidence to show that the presence of fluoride in water results in a substantial reduction of dental caries in both children and adults. However, long term consumption of water above the permissible level can give rise to dental fluorosis, manifested by mottling of teeth and higher exposures can give rise to skeletal fluorosis, a crippling disease in which bone structure is affected.

There are several other inorganic chemicals like cadmium, lead and organic chemicals like pesticides, polynuclear aromatic hydrocarbons, etc. that can cause health hazards in man after prolonged exposure above permissible levels.

Also, radioactive substances, in surface and groundwater, either from natural sources or from human activities, can pose serious health hazards and have become an important issue internationally after the Chernobyl accident. However, these are as yet, not of great public health importance in India.

3. Water — Sanitation & Health — Need for an Integrated Approach:

A perusal of Table 2, makes it apparent that water alone has limited value in control of water and excreta related diseases. An integrated and community based approach, providing appropriate importance to water quality & availability, excreta disposal, personal hygiene, etc. need to developed, through effective intersectoral co-ordination and active community participation.

Though a spectacular success has been achieved in terms of water supply coverage in India and many Third World countries during the Water Supply and Sanitation Decade, sanitation has ever remained a low priority area. Water and sanitation related diseases are still continuing to be high. It is a pity that we failed miserably in managing our liquid and solid wastes which has become one of the most pressing public health problems in both rural and urban areas. We have equally failed in our task to motivate and make people aware of the importance of Environmental Sanitation. The recent resurgence of Plague and Malaria bear testimony to this. The explosive outbreaks of Haemorrhagic Dengue Fever in recent years is another pointer to the low standard of urban and peri-urban sanitation. The almost annual phenomenon of Diarrhoeal diseases in most Indian states, points to our total failure to supply safe water and excreta disposal facilities. Practice of open defecation specially in the rural areas remains an important hurdle in breaking the transmission routes of many of the water and sanitation related diseases. According to a report published by UNICEF (The State of the World's Children, 1994), the Indian people's accessibility to adequate sanitation has been estimated to be 53% in urban areas vis-a-vis a meagre 2% in rural areas (country-wise overall: 16%).

The situation in respect to sewerage and sewage/waste water treatment in India is equally grim. Out of over 3000 Indian cities and towns, only 217 have sewage treatment facilities. It is estimated that only about 50% of the generated waste water is collected in metropolitan cities and remaining passes on to the surface, creating degradation of environment.

4. Water Pollution and its Impact on Community Health :

Water pollution (excepting a few instances of naturally occurring cases), which has been ever on the rise and has since assumed critical proportion, started with the disposal of sewage and industrial effluents into the rivers or water bodies and lack of sanitation facilities and has been linked to population growth, lack of foresight and ill-planned human activities.

Most of our rivers are getting polluted from the discharges of untreated sewage or sullage from urban areas, discharges of industrial waste-water, dumping of solid wastes in river or from leachates of solid waste dumps close to the river. The lack of waste water management has caused serious deterioration in the quality of river water and as such, there is an urgent need for abatement of such water pollution by establishing rational waste water management techniques.

4.1 *Uses of Water :*

Inherently water is a multiple use resource. Thus, the uses of most rivers and lakes are multiple, often conflicting. However, the general areas of water use having specific quality requirements are :

Recreation and aesthetics;
Public water supplies;
Propagation of fish, other aquatic and wild life;
Agriculture;
Industry.

Obviously, in order for any water body to function adequately in satisfying any one or more of the above purposes, it must have a corresponding degree of purity conforming to the quality requirements for the identified best usage of the water body. This has led to the development of water quality criteria for the various beneficial uses as well as setting of streams standards in most of the countries in the world including India. Furthermore, many rivers and lakes serve as sinks for wastes, of course, with dire consequences in most cases.

4.2 *Point and Non-Point Sources of Pollution and their Impact on Health :*

Almost all social or productive uses of water introduce pollutants into it. However, the principal burdens on water quality come from :

- ☐ Households (Municipal)
- ☐ Industry
- ☐ Agriculture

The first two categories of wastes constitute point sources as they are discrete, readily identifiable and are amenable to direct control. The agricultural return waters, on the contrary, are more diffused as regards their origin and distribution and reach natural water sinks through land run off or other means and are termed non-point sources. Recognition of the seriousness of non-point sources of pollution has increased during the past years, but there has been little constructive progress in its regulation. The water pollutants stemming from point sources may be broadly classified as oxygen demanding substances, organic and inorganic chemicals, organic chemical exotics including insecticides, pesticides and detergents; radioactive substances, and heat from power and industrial plants. The total list of individual pollutants under the above categories is extremely lengthy. The latest water quality criteria for the beneficial uses enumerated earlier as published by U.S. Environmental Protection Agency (EPA) encompass nearly seventy water quality constituents. Furthermore, there is a continuing lengthening of the spectrum of pollutants as newer chemicals and substances are coming up steadily with newer process developments.

Among the various contaminants causing water pollution, pesticides have raised strongest public concern and have contributed markedly to the general uneasiness associated with the pollution-related hazards for the last two decades. Pesticides are known to contaminate the environment viz., air, water and soil, and thereby affect the human health. With the expanded use/demand of pesticides as depicted in Table 4, it is inevitable that most foods will often contain residues of these substances. The sources of residues in food may be *Direct or Indirect*. Agricultural procedures directly related to production are the most obvious source of residues. The indirect sources can occur for example, in crops grown in soil previously treated or contaminated by treatment of other crops grown earlier. Large amounts of pesticides used for purposes other than food production, such as, for disease control, protection of fibre crops and forests, etc. may be transported by air, and water movements.

TABLE 4

Estimated demand of pesticides during (1991-92) based on actual consumption (1988-91) prepared by Pesticides Association of India

Pesticides	Actual Consumption			Estimated Demand
	88-89	89-90	90-91	91-92
Insecticide	67,692	56,424	47,074	48,730
Fungicides	16,365	17,530	17,770	18,635
Herbicides	4,160	4,730	4,862	5,205
Rodenticides	950	850	1,000	950
Fumigants	70	75	75	75
Total :	**89,237**	**79,609**	**70,781**	**73,595**

Reports of mass mortality of several varieties of fishes in rivers and ponds have been received from time to time from different quarters. In 1975, several kilometres of a river in West Bengal were affected by pesticides and fish mortality continued for about 7 days killing several tons of fish. While histopathological effects of the pesticides in many organs of the fish which were mostly irreversible were the main reasons for fish mortality, effects on feeding habits of fish resulted in reduced growth and reproduction of fish. Reduced feeding habits lead to poor growth in fish and also the normal production is hampered.

Several pesticides leave residue in water, mud, invertebrate organisms and also in fish body. The residues are several times greater in the fish bodies than in water. Fish may grow resistance and may tolerate heavy doses of pesticides in their bodies. These contaminated fishes were potential hazards not only to carnivorous fishes but also to many wildlife.

5. Ground Water Quality and Related Health problems in Rajasthan :

Owing to poor surface and sub-surface drainage, the ground water in parts of Rajasthan is highly saline. Because of poor ground water quality, often the people were compelled to use polluted surface water from ponds and step wells. Prevalence of step wells made Rajasthan one of the States which were critically affected by guinea worm. In 1984 there were 15,210 cases of guinea worm in 23 districts having population of 48,49,340. Though the disease is almost eradicated from the rest of the country, still there have been 348 cases in Rajasthan in 1994 in 11 districts. With the concerted efforts under the National Drinking Water Mission for providing safe water sources, it is no more a critical health problem.

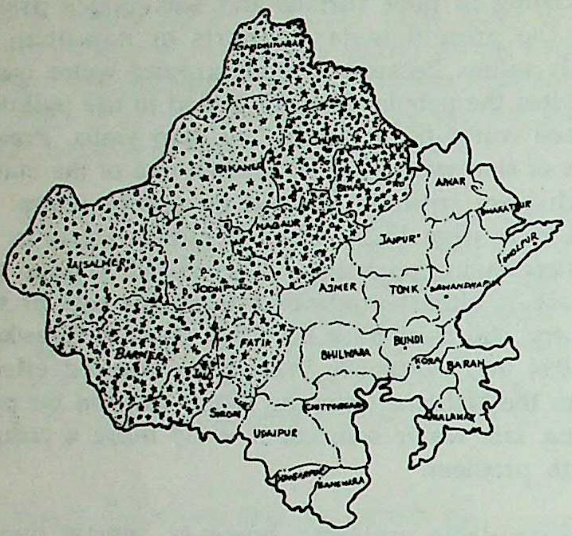
Formidable problems, however, remain owing to excessive concentration of health affecting constituents in ground water, particularly Nitrate and Fluoride. The distribution of hydro-chemical parameters in ground water in Rajasthan is shown in the figure, next page.

5.1 *Health Hazards Associated with Fluoride and Nitrate :*

A review of the hydrochemical parameters of ground water of the districts of Rajasthan reveals that the arid areas of Barmer, Nagaur, Churu have formidable quality problem, i.e. apart from high salinity of the ground water, they are having two critical health hazards, viz. Nitrate and Fluoride. In Nagaur the problem is extremely critical and needs immediate attention as because in many areas it has been reported that more than 70% of the ground water sources have Nitrate higher than the permissible limit and 50% of ground water sources have fluoride value greater than 1.5 mg/l. In other districts nearly 76% ground water sources have nitrate value more than 100 mg/l. The maximum nitrate concentration in Churu and Barmer are 2400 and 1900 mg/l respectively. In these districts maximum Fluoride contents of ground water are 30 mg/l and 13 mg/l. Even in the Southern districts of Ajmer. Bhilwara, Dungarpur and Kota, Fluoride in ground water is a matter of deep concern, as more than 25% ground water sources in these districts have Fluoride content more than 1.5 mg/l. At many places this value exceeds 5 mg/l. Maximum values reported from Ajmer and Bhilwara districts are as high as 16 and 10 mg/l respectively.

Fig. 1

Distribution of Hydrochemical parameters in Arid Rajasthan



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Symbol	Type of Water
░	Fresh Water
●	Problem of Salinity
○	Problem of Nitrate
★	Problem of Fluoride

In the light of the above discussion it would be pertinent to evaluate the seriousness of health problem associated with these chemicals. No other naturally occurring chemical in drinking water has been given so much importance as Fluoride. Fluoride in water is almost completely absorbed and distributed rapidly throughout the body. Dental fluorosis in children in the age group between 7 to 12 years is common with consumption of water having fluoride above 1.5 mg/lit. Skeletal fluorosis has been reported in water containing fluoride level 3-10 mg/lit. There have been reports of thyroid or kidney problems with water containing fluoride in excess of 20 mg/lit. The presence of high nitrate not only causes methemoglobinemia in children when present in considerable quantity, but has also been reported to cause cancer. Though the level of Nitrate in many parts of Rajasthan could cause serious health problems, no scientific epidemiological risk assessment has been undertaken as yet. Though epidemiologically some corelation has been shown to occur between Nitrate and stomach cancer, epidemiological evidence of methemoglobinemia in children is very scanty.

While, some concrete measures have been taken in relation to control of Fluorosis, the situation in respect of Nitrate is rather confusing. A rational and pragmatic assessment of the epidemiology and health risks of Nitrate in ground water in Rajasthan is long over due and needs to be undertaken urgently. Often, high Nitrate in ground water, has been associated with on-site sanitation systems and leaching pit latrines. Public Health Engineers, on occasions, have resisted low-cost sanitation systems on this ground. Numerous sources in the environment contribute to the total nitrate content, viz, geological sources, anthropogenic sources, atmospheric nitrogen fixation, soil, agriculture & waste disposal. On-site sanitation could at best contribute a very minor fraction. States like West Bengal, Assam, Kerala, with large no. of pit latrines, have less than 5 mg/l of No_3 in ground water. Creating undue panic and resisting low cost sanitation programme would be counter productive from point of view of public health. Instead efforts should be made to develop cost effective biological methods of nitrate removal.

6. Concluding Remarks :

It has to be accepted, that Health Benefits have not been commensurate with the investment made in the water supply sanitation sector. Low priority to sanitation apart, our total failure in ensuring safety and quality of public water supply needs serious review.

Health and Community Water Supply authorities in general and Public Health & Municipal Engineering in particular, owe an explanation to the community. Resource constraints, administrative and managerial inefficiency or inappropriate technology — wherein lies the problem ? What are the technical and managerial answers to these problems ? What sorts of socio-behavioural and educational support programmes are required ? The authorities concerned need to ponder very seriously over the reasons for the failure to maintain water quality in public distribution systems in the urban and peri-urban areas. In the rural areas, breakdown of large number of hand pumps and use of grossly polluted pond water for domestic uses are considered to be the major contributing factors behind the spread of water borne diseases.

So far our approach has been ad hoc, piecemeal and sectoral. The problem in reality has to be tackled on many fronts. Not only water supply but sanitation has to be given due emphasis. In a country like ours being faced with severe resource constraints, a community based approach appears to be the only viable option for water quality and environmental management.

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Water Resources and their Management in the Indian Arid Zone

Dr. A. S. Faroda*

Water is an important factor in all parts of life and plays a key role in the development of agricultural sector. In the arid and semi-arid regions water is the prime and precious natural resource, for these regions are critically deficient in water resources. Within the arid regions, the need for water is becoming more and more critical each year, as increasing urban and expanding industrial and agricultural demands put more pressure on existing supplies. Thus, there is an urgent need to assess and evaluate the water resources and their dynamics for efficient management so as to reverse the process of desertification in the Indian arid zone.

Indian Arid Zone :

The arid zone of India covers about 12% of the country's geographical area, and occupies about 32 million ha in parts of Rajasthan (61%), Gujarat (20%), Punjab and Haryana (9%), and Andhra Pradesh and Karnataka (10%). An area of about 0.7 million ha of cold desert in Ladakh and J. & K. plateau has entirely a different set of agroclimatic conditions. The bulk of hot arid zone of Thar is located in the state of Rajasthan. It comprises the 12 western districts of the state, viz., Barmer, Bikaner, Churu, Hanumangarh, Jaisalmer, Jalore, Jhunjhunu, Jodhpur, Nagaur, Pali, Sikar and Sri Ganganagar. In Gujarat, the arid belt is largely coastal extending from Rann of Kutchh to Jamnagar and parts of Surendranagar, Junagarh, Banaskanta, Mehsana, Rajkot and Ahmedabad. Ferozpur, Bhatinda, and Sangrur districts in Punjab fall in the arid region. In Haryana the districts of Hisar, Sirsa, Bhiwani, and part of Mahendragarh fall in the arid region.

The Indian arid zone is dominantly sandy, has disorganised drainage network over major part, deep and often saline ground-water, and high rates of evaporation. Spatially, the eastern margin of the desert receives about 500 mm of rainfall per annum along the Aravallis to less than 100 mm in the west in Jaisalmer district. Added to this decreasing rainfall gradient westward there is an increasing gradient of year to year variability in rainfall. It is less than 40% in Sikar and Jhunjhunu districts in the east, and more than 70% in the western part of Jaisalmer district. The main rainy season is from June to September, when 90 to 95% of the total annual rainfall is received. The winter rainfall accounts for the rest 5 to 10%, and is associated with the western disturbances. The east has a better drainage network and a better prospect of water availability. Yet, the demand for water is increasing steadily, as human and livestock populations are increasing, more and more land is being brought under irrigated agriculture and newer industries are being set-up.

Hydrological Zones :

Hydrologically the Thar desert and its adjoining arid areas in India can be divided into three zones:

Zone I : Region with major input of water from more humid regions, with extensive irrigated agriculture :

This zone comprises of the arid districts within the states of Punjab and Harayana (Bhakra Canal System) and the north western part of Rajasthan (Indira Gandhi Canal). It occupies nearly 42,900 km².

Zone II : Plain land with a primitive or no stream network :

This zone occupies the desert districts in the state of Rajasthan and a part of Gujarat with an area of nearly 148,600 km². It contains no integrated stream network in the conventional sense. Rather, there is a system of repetitive micro-hydrology. A large-scale surface hydrology is active only in extreme events. The inhabitants of this region are partly dependent on surface water, i.e., harnessing the runoff in the form of village ponds (*nadis*) and underground cisterns (*tankas*). About 65% of this zone has mineralized groundwater having total dissolved solids of over 3200 ppm (Chatterji et al., 1988). Besides, groundwater is available at 40-100 m depth. The discharge potential is poor to the extent of 1 l s^{-1}.

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Zone III: Sloping region with an integrated stream network:

Luni River and its tributaries in the state of Rajasthan and disorganised drainage systems in the state of Gujarat constitute this zone which, together, covers 94,280 km^2. These are ephemeral channels and remain dry for a large percentage of time. When runoff does occur, a large proportion of the stream flow is absorbed in the beds and banks of the channels. Such transmission losses are sufficient to cause the stream flow to disappear altogether before reaching its ultimate outlet. The baseflow is typically absent. There are a number of medium and minor irrigation projects in this zone.

Assessment of Surface Water Resources:

Zone I: Within this zone the three districts in the state of Punjab, viz., Ferozpur, Bhatinda and Sangrur, get water from the Bakra-Nangal Project on the Sutlej River through canals, since they lie in zone III of the Bhakra canal project (Murthy and Gulati, 1978). The water allowance for 100 ha is 0.24 cumec for perennial canals and 0.42 cumec for non-perennial canals. The Ferozpur feeder and the Bhakra canals have designed capacity of 314 and 510 cumecs, respectively (Uppal, 1978).

In the state of Haryana, Sirsa, Hisar, Bhiwani and Mahendragarh districts receive water from the western Yamuna and Bhakra canals, diverted from the rivers Yamuna and Sutlej, respectively. Water allowance for 100 ha varies between 0.157 and 0.192 cumec (Gupta, 1987). The canal water potential in the arid districts of Haryana is presented in (Table 1). The western Yamuna canal has been designed to convey 79.3 cumec of water.

TABLE 1

Districtwise canal water potential in the arid districts of Haryana

District	Canal water supply in use (cumec)	Running days/yr	Canal water potential (m.cum)
Sirsa	81.24	240	1700
Hisar	135.75	240	2841
Bhiwani	66.74	100	582
Mahendragarh	79.29	100	1096

The Indira Gandhi Canal network in the vast sandy tract of northwest Rajasthan has its origin at the Harike Barrage on the Sutlej river in Punjab. Since the water allocation is based on evaluation of reservoir storage, river inflows and inter-state water demand, the canal system experiences significant levels of uncertainty and variability in the water supply from time to time. At present the capacity of the main canal is 524 cumec (Kapoor and Rajvanshi, 1977) and the volume of water conveyed through it has to be primarily for (i) irrigation in stage-I area, and (ii) drinking water requirements, (iii) construction and irrigation in stage-II area.

The flow volume in the main Indira Gandhi Canal varies from 1727x10^6 to 2961x10^6 m^3 in different seasons (Anonymous, 1988). The average daily discharge varies from 113 to 227 cumec for more than 80% of the time period, which is less than half of the design discharge. Between 1982 and 1986 the water flow at the head of the main canal increased from 2965 x 10^6 to 5144 x 10^6 m^3 — an increase of 30%, while the water flow, expressed as depth of water per ha of irrigation, is at the rate of 5.24 m ha^{-1} (Table 2).

TABLE 2

Characteristics of water delivery in the Indira Gandhi Canal

Parameter	Year				
	1982	1983	1984	1985	1986
Total flow (m^{3}x10^{10})	0.3963	0.4205	0.4456	0.5068	0.5143
Mean daily flow (m^{3}x10^6)	11.73	12.57	10.91	13.53	15.18
Water supplied (m ha^{-1})	5.05	4.97	5.68	5.40	5.10

Irrigation in the Indira Gandhi Canal command is being practised without adequate attention to long term side effects of waterlogging, soil salinity, depletion of natural pastures, increased soil erosion and environmental deterioration. Out of 7000 km^2 area in the stage-I, 513 km^2 are waterlogged (Bithu, 1985). In stage-II large chunks of scattered waterlogged land and scattered water in the depressions exist along the running portion of the main canal. The loose fine sand deposits over clay beds or massive calcium carbonate gypsum rock in the shallow substratum not only develop water logging or soil salinity on intensive irrigation, but also create conditions favourable for liquification and sinking on cyclic stress application by machines and walking cattle. About 3540 km^2 area in the stage-II is potentially vulnerable to waterlogging on irrigation as the hydrological barrier is within 10 m depth. The plains have characteristical/stratified soils with gypsiferous/calcarious/clay/rock/hard pan and an aeolian sand overburden. Indiscriminate alteration of the naturally grass covered sandy plains into intensively irrigated field crop areas in the stage II may soon upset the ecological and hydrological balance of the region. The areas having hard pan or barrier at shallower depth may develop high perched water table and become waterlogged in due course of time.

Zone II : This zone comprises of sandy plains, interdune plains, sand dunes, eroded rocky/gravelly surfaces and isolated hillocks. The channels emanating from these hillocks and rocky/gravelly surfaces get suffocated in deep alluvium or blown sand and form internal drainage basins.

The inhabitants in this region harness the meagre precipitation in small earthen dugout/embankment ponds called *nadis* and in underground cisterns called *tankas*. This is an ancient practice. Water in the *nadis* and *tankas* is consumed by human and livestock population and is available for 2 to 12 months, depending upon the drainage basin characteristics, the amount and intensity of rainfall and its distribution. The *nadis* range from 1.5 to 12 m in depth, 400 to 70000 m^3 in capacity and have catchment area of 8 to 2000 ha. *Tankas* are constructed on individual household and community basis. These are circular in shape, having almost similar depth and diameter, the value ranging from 3 to 6 m. The size of the catchments may vary from about 400 m^2 to 2 ha, depending upon the expected runoff and availability of spare land with each family.

According to Jain (1968) approximately 580x10^6 m^3 surface water is available annually for utilization in this part of the Thar. Mehta and Kashyap (1970) estimated the surface water potential in this region as 192x10^6 m^3, out of which 127x10^6 m^3 is the total utilizable surface water potential. Sharma (1991) estimated the surface water potential of this zone as 1330x10^6 m^3, out of which about 17% is presently utilized.

The stored water in reservoirs and small ponds (*nadis*) is subjected to high evaporative and seepage losses. The highest evaporative losses were observed during the period March-June, i.e., in the driest season when the demand for water was highest. High evaporation also occurred in October and November after the rainy season. Seepage losses were greatest during the rainy season (July to September), when the storage structures were completely filled. Evaporative losses varied from 55 to 80% of the total losses. The seepage losses were of the order of 20 to 45%, the highest being in sandy terrain. Annually the evaporative losses of stored water in the Indian arid zone varied from 1505 to 2473 mm whereas the seepage losses ranged from 666 to 1494 mm (Sharma and Joshi, 1893).

Zone III : In this zone no regular long term stream gauging has been done to establish the amount of surface water available at various localities. However, efforts were made to compute the water potential through the use of rainfall data that were available for a long period. The rainfall, along with temperature record, makes it possible to apply the empirical formulae for such computation.

The first serious attempt in this direction was made by Dhir and Krishnamurthy (1950). They concluded that there was nearly 518x10^6 m^3 of available surface water potential in the Luni Basin out of which 284x10^6 m^3 (55%) surface water potential was estimated to be utilizable. Dhruvanarayan et al. (1964) estimated the surface water potential of the Luni Basin as 571x10^6 m^3, on the basis of the monsoon rainfall over the region and by using empirical formulae. Mehta (1970) on the other hand, estimated the surface water potential of the Luni Basin as 868x10^6 m^3, out of which 673x10^6 m^3 (77.5%) was recognised as the utilizable potential. Mehta and Kashyap (1970) reported 939x10^6 m^3 as the surface water potential in the basin and 403x10^6 m^3 (43%) as the present utilization. They further estimated the surface water potential of western Rajasthan as 1132x10^6 m^3 (Table 3). According to the another estimate (Anonymous, 1980) the surface water potential in the Luni Basin is 858x10^6 m^3, out of which 700x10^6 m^3 (82%) is utilizable potential.

TABLE 3

Surface water potential of Western Rajasthan

Region	Basin area (km^2)	Total runoff (m.cum)	Total use (m.cum)
Sukri River Basin	945	58	13
Other streams of Jalore district	471	13	5
Luni River Basin	34639	869	386
Basins of the Shekhavati tract	5885	192	127
Total :		1132	531

Rao (1975) estimated the annual runoff from desert rivers of India as 9943.2x10^6 m^3. Out of it 8000x10^6 m^3 was calculated as the annual discharge in the Luni and its tributaries. The desert rivers together contribute 8% runoff of all the river systems in India.

Stream gauging on the Luni and its tributaries between 1979 and 1987 revealed that the annual flows in the rivers were highly variable (Table 4). The mean basin outflow was recorded as 836.8x10^6 m^3 and could be taken as surface water potential. However, the actual surplus varied from 70x10^6 m^3 to 3898x10^6 m^3 during this period.

TABLE 4

Water potential in the Luni Basin (Mean 1979-87)

River	Peak discharge (cumec)	Flow volume (m.cum)
Jojri	58.9	10.2
Luni	125.8	30.0
Guhiya	1065.2	344.6
Bandi	348.7	100.3
Sukri	395.5	62.4
Mitri	313.6	20.8
Jawai	541.9	71.4
Kharibandi	1580.7	134.5
Khari	278.5	18.1
Sagi	185.3	44.5
Total :	—	836.8

In arid part of Gujarat state there is no major river, but numerous ephemeral streams flow in direct response to the torrential rainfall, and are both flashy and shortlived. Rao (1975) estimated the annual average discharge of these rivers as 1160x10^6 m^3, out of which 430x10^6 m^3 is carried by two significant rivers, viz., the Shetrunji and the Bhadra on the southwest coast.

Patel (1988) estimated the surface water potential of Kutchh District as 1049.21x10^6 m^3, out of which 826.21x10^6 m^3 flow to the sea or the saline Ranns. The surface water potential in the arid part of Gujarat State ranged between 567.98x10^6 m^3 and 2954.- lx10^6 m^3 during 1981-87 (Anonymous, 1989).

Large quantities of sediment are generated and transported in the ephemeral channels due to torrential rainy spells, excessive weathering, sparse vegetative cover, aeolian deposits within the catchments, and biotic interference. The sediment not only deteriorates the water quality but also substantially reduces the storage capacity of water bodies (Sharma and Chatterji, 1982). The magnitude of the seidment deposition is governed by the catchment characteristics (Table 5).

TABLE 5

Annual reduction in the storage capacity of water bodies in the Indian arid zone

Physiography	Annual average sediment yield (cum/h)	Annual reduction is storage capacity (%)
Sandy plain	3.1	1.9
Dune complex	4.8	2.2
Younger alluvial plain	2.7	3.4
Older alluvial plain	18.4	5.3
Rocky/gravelly pediment	14.3	7.8

Assessment of Groundwater Resources :

In the Indian desert sandstone and limestone aquifers were found promising for tapping moderate to potential supplies of groundwater due to their porous and permeable nature (Anonymous; 1986a, 1986b). The blown sand also forms moderately potential aquifers in places. In the hard rocky terrain, the valley fills along the streams consisting of river alluvium often contain highly productive aquifers, although their productivity is limited and yield is low (5-25 m^3 h^{-1}). The alluvium contains the most productive aquifers in the region but locally the quality of groundwater is poor. Among the semi-consolidated formations the Lathi sandstone (Anonymous, 1981) is found to contain moderately to highly productive aquifers (water yield varying from 25 to 150 m^3 h^{-1}). Overall, the groundwater resources in this region are estimated to be 4540x10^6 m^3 out of which net recoverable recharge is 3830x10^6 m^3. In Gujarat the groundwater bearing formations are shale and limestone and thus, the quality of groundwater is poor in general. According to an estimate (Anonymous, 1986b) the recoverable recharge from all aquifers in the Gujarat desert is 1270x10^6 m^3. The range of total dissolved solids varies from 0.5 to 2.5 g l^{-1}. Wells tapping the alluvium and hard rock aquifers in Punjab and Haryana yield 3.6 to 10 m^3 h^{-1} and 1.7 to 3.3 m^3 h^{-1}, respectively.

It has been worked out in the arid part of Rajasthan (Anonymous, 1986a) that the development of groundwater is considerably low, i.e., below 5% in Jaisalmer, Bikaner and Churu districts, whereas it is moderate, i.e. between 25% and 45% in Nagaur, Ganganagar, Barmer and Jodhpur districts. In case of Jhunjhunu, Sikar, Jalore and Pali districts the development of groundwater has shown considerable growth, i.e., between 70% and more than 90%. It is also important to note that in a number of development blocks the development of groundwater has already exceeded the annual recharge and as such these blocks have attained 'over-exploited', 'grey' or semi-critical and 'dark' or critical stages of groundwater development (Table 6).

TABLE 6

Development blocks with excessive groundwater development in arid Rajasthan

'Over exploited' (Draft > recharge)	'Dark' (> 80%)	'Grey' (65-85%)
Dhorimanna	Saila	Chirawa
(Barmer)	(Jalore)	(Jhunjhunu)
Bhinmal	Udaipur	Osian
(Jalore)	(Jhunjhunu)	(Jodhpur)
Sri Madhopur	Rohat	
(Sikar)	(Pali)	

With the over-exploitation of groundwater, the water table is receding by almost one m per annum. The yield has also decreased by one-third over the last few years and the salt content is gradually increasing. Over 60% of groundwater is now saline, containing salts from 1500 to 3000 ppm. Thus, the problems of groundwater are low/limited water supply, and poor quality (Abrol and Venkateswarlu 1995). Large chunks of land have since come under dark zone category due to mining of groundwater.

Utilization of Water Resources :

The priorities of water utilization in the Indian arid zone are : (i) drinking water, (ii) grassland irrigation, (iii) crop land irrigation, and (iv) industries.

Accordingly, after meeting the drinking water demand in zone I, the canal water is used for irrigating the grasslands and crop lands (Kapoor and Rajvanshi, 1977). The Indira Gandhi Canal serves an area of nearly 0.95×10^6 ha in the stage-I and 1.10×10^6 ha in the stage-II. At present the intensity of irrigation in the command area is 110% (April-September 47%, October-March 63%).

In zone II nearly all the water resources are used for drinking by the human and livestock (Sharma, 1991). Cropping on conserved moisture and with life saving irrigation is done in a very small area and is negligible. These waters are available only during the good monsoon years. The estimated surface water use in this region is 16200×10^6 m^3 (Sharma, 1991).

In zone III about 673×10^6 m^3, water still remains unutilized. The total number of medium and minor irrigation projects in the Luni Basin is 207 (Anonymous, 1980). These projects, with a storage capacity of 658×10^6 m^3 supply irrigation water to nearly 10,000 ha. In the Kutchh district the present water utilization is as follows :

Annual water yield	1049.21×10^6 m^3
Requirement for drinking	4.00×10^6 m^3
Requirement for irrigation	219.00×10^6 m^3
Balance	826.21×10^6 m^3

There are 84 medium and minor irrigation projects in the arid part of Gujarat, with a storage capacity of 2024.51×10^6 m^3. During an average rainfall year these provide irrigation water to 247,531 ha of land (Anonymous, 1989).

Low and erratic rainfall, harsh climatic conditions, pollution of stored water and discharging industrial effluents in ephemeral channels resulting in groundwater pollution are other factors hindering the efficient utilization of water resources in the Indian arid zone.

Management of Water Resources :

Canal Command Area : In the canal command area, the irrigation demand changes with the cropping pattern and crop characteristics. Cropping pattern is also known to have changed gradually under the influence of agro-economic conditions. Development of new crop varieties, prices of agricultural commodities, social needs, demand-supply position in the national and international markets, etc. bring about periodical changes in the cropping pattern. Since water availability for the Indira Gandhi Canal stage-II is likely to be limited, emphasis should be on the prasticing of extensive irrigation, rather than intensive irrigation.

The areas highly vulnerable to waterlogging and salinity should be used for cultivation of grasses, with utmost control on water application through sprinkler irrigation. Drip and sprinkler irrigation systems would be of help in preventing or delaying the process of rise in groundwater table in the vulnerable areas. The most vulnerable areas having barrier at 5 m or at less depth need to be surveyed and monitored in detail. Inverted well should be constructed in the critical area for effective drainage.

The principle of volumetric sale of water should be introduced and strictly enforced. Water should be diverted to the lined tanks only, from where it may be pumped out with wind or solar energy, so that only the most needed quantities are purchased, no flooding is done and optimum utilization of this scarce resource is ensured. Similar experiments in China have proved successful. Although construction of such small ponds will add to the cost, considering the problem of ecological imbalance, the possibility should be explored.

As has been mentioned earlier, attention has to be given in the region on new irrigation technologies like sprinkler and drip irrigation, since these systems make the best use of every drop of available water by drastically reducing the conveyance and deep percolation losses. The feasibility of using sprinkler system on individual farm should, however, take into consideration the prevailing wind velocity in the region and the cost of infrastructure development, like storage tank construction. The drip system, on the other hand, is neither for all farmers, nor for all crops. It has particular promises for high-value, widely-spaced vegetables and plantation crops on porous soils of the water scarce regions. Also the need for a proper drainage system is hardly to be over-emphasised in the canal command areas.

Water Conservation : The pace of research and development work on efficient conservation of water needs also to be accelerated. This includes improving the designs of the low-cost traditional water harvesting systems like *tankas, nadis, khadins,* etc., and designing of suitable structures for conserving water with limited evaporative losses. The possibilities of injecting the surplus flood water into shallow subsurface aquifers for storage without appreciable deterioration of quality for future reuse also need to be examined. Such experiments in the saline depressions of the Karakum desert in Russia and in the semi-arid sandy plains of the Sahel region in Africa are claimed to have limited success.

Groundwater Monitoring and Development : The management of groundwater resources in arid regions requires special attention due to the fact that it occurs under complex hydrogeological environments. Groundwater forms the most reliable resource for human and livestock consumption in this region. Therefore, its exploitation for domestic purpose is the highest priority agenda. The utilization of groundwater for irrigation has also been increasing due to the spreading network of electricity. Under the circumstances it is important to review the groundwater assessment in the region annually and to suggest the limit for safe yield. Artificial recharge methods should also be adopted so that proper groundwater balance can be maintained. A comprehensive legislation for utilization of groundwater resources should be framed and the people should be educated regarding proper utilization of groundwater resources.

Conclusion :

The water resources in the arid zone of India are extremely variable both in the quantity and quality, and are undependable. Withdrawal of groundwater, at present, reflects only a tiny proportion of the fossil and/or recharging water contained in the various potential aquifers throughout the region. However, quality of the groundwater is a constraint for their enhanced use.

Presently, the available water resources in the region have been stretched to the limit as a result of increased demand for drinking, agricultural and industrial use. If this trend continues, there is a danger of destroying or depleting the water resources beyond recovery, i.e., over use, over pumping and increased salinity. A long term planning for water management and water use is a prime need of the hour.

References :

Abrol, I. P. and Venkateswarlu, J. (1995) Sustainable development of arid areas in India with particular reference to western Rajasthan. In : Land Degradation and Desertification in Asia and the pacific Region (ed. A. K. Sen and A. Kar), 135-153. Scientific Publishers, Jodhpur.

Anonymous, (1980) *Master Plan of Luni River Basin.* Irrigation Department, Jodhpur, 217 p.

Anonymous (1981) *Report on the Working Group of Arid Zone Research.* Department of Science and Technology, New Delhi 128 p.

Anonymous (1986a) *Report of the Group on the Estimation of Groundwater Resources and Irrigation Potential from Groundwater in Rajasthan State.* Central Groundwater Board, Jaipur, 46 p.

Anonymous (1986b) *Report of the Group on the Estimation of Groundwater Resources and Irrigation Potential from Groundwater* *in Gujarat State.* Central Groundwater Board, Gandhinagar, 54 p.

Anonymous (1988) Study of water management strategy for Indira Gandhi Nahar Project. *Draft Final Report.* Operations Research Group. Baroda, 62 p.

Anonymous (1989) *Major and Medium Irrigation Schemes in Gujarat State.* Water Resources Department, Gandhinagar, 20 p.

Bithu, B. D. (1985) Environmental impact assessment of water resources projects in arid region. In: Proceedings of International Seminar on Environmental Impact Assessment of Water Resources Projects. Roorkee; 62-87.

Dhir, R. D. and Krishnamurthy, K. V. (1952) The hydrology of the Rajasthan Desert. *Bulletin of the National Institute of Sciences of India,* 1: 211-216.

Dhruvanarayan, V. V. Sriniwas and Murthy, K.N.K. (1964) Efficient use of water resources in Indian arid zone. In : *Proceedings of the International Symposium on the Problems of Indian Arid Zone,* New Delhi 25-27.

Gupta, M. C. (1987) Possibilities of mixing of brackish and saline groundwater with fresh water in canals and water courses. In : Studies for Use for Saline Water in the Command Areas of Irrigation Projects, Haryana. Hisar, 47-49.

Jain, J. K. (1968) *Resources and Potentialities of Rajasthan.* Ph.D. Thesis, University of Jodhpur, Jodhpur, 278 p.

Kapoor, A. S. and Rajvanshi, B. S. (1977) The Rajasthan Canal Project. In : *Desertification and its Control,* 121-129. Indian Council of Agricultural Research, New Delhi.

Mehta, H. S. (1970) The Luni Basin. In : *A Search for Water,* 29-36. Sarjana Prakashan Publication, Jaipur.

Mehta, H. S. and Kashyap, S. (1970) Water potential of Rajasthan. In : *A Search for Water,* 109-114. Sarjana Prakashan Publication, Jaipur.

Murthy, V.V.N. and Gulati, H. S. (1978) Optimal use of canal waters in the Indus Basin. In : Proceedings of the National Symposium on Land and Water Management in the Indus Basin, Ludhiana, 156-166.

Patel, C. C. (1988) Long term perspective of rural drinking water supply within an overall framework of total water resource development in the Kutchh District. Final Report. Govt. of Gujarat, Gandhinagar, 257 p.

Rao, K. L. (1975) *India's Water Wealth.* Orient Longman, New Delhi, 255 p.

Sharma, K. D. (1991) Water resources - an overview of the world deserts. *Annals of Arid Zone,* 30 : 283-300.

Sharma, K. D. and Chatterji, P.C. (1982) Sedimentation in *nadis* in the Indian arid zone. Hydrological Sciences Journal, 27 : 345-352.

Sharma, K. D. and Joshi, D. C. (1983) Optimization of *nadi* characteristics to minimize evaporative and seepage losses. Journal of Arid Environments, 4 : 247-251.

Uppal, H. L. (1978) Hydrological balance of the Indus Basin. In: *Proceedings of the National Symposium on Land and Water Management in the Indus Basin,* Ludhiana, 1-50.

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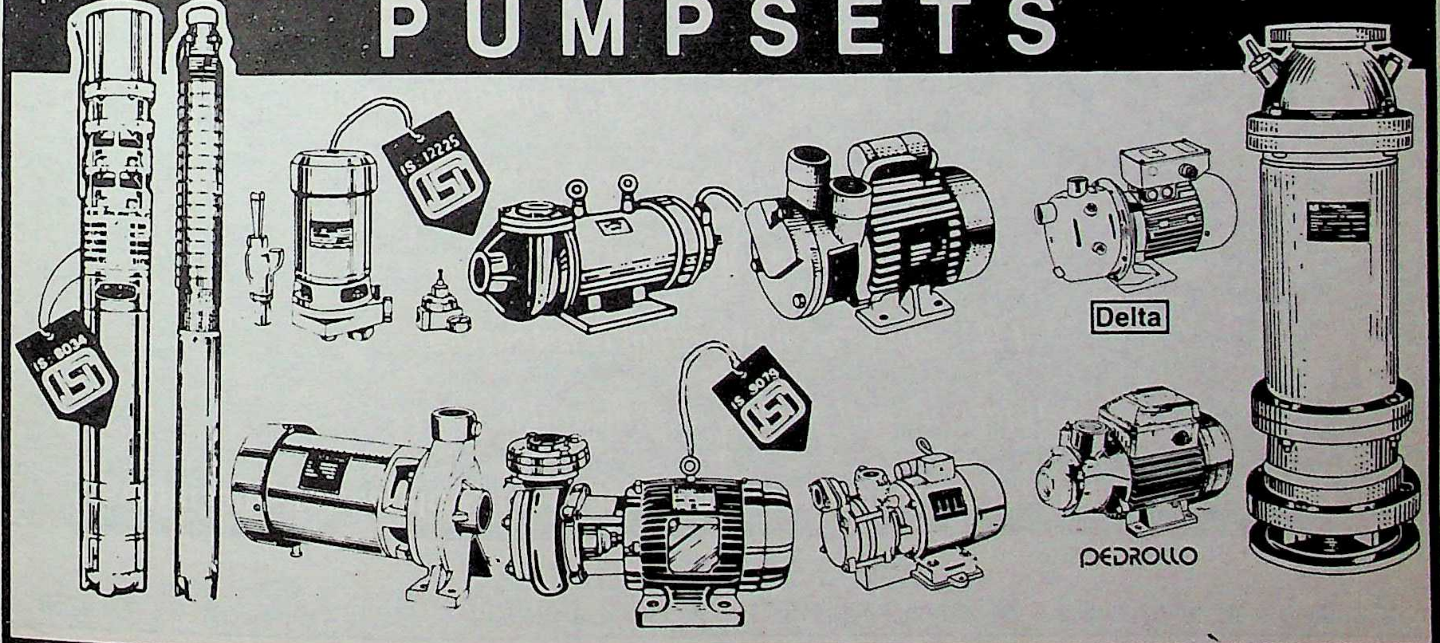

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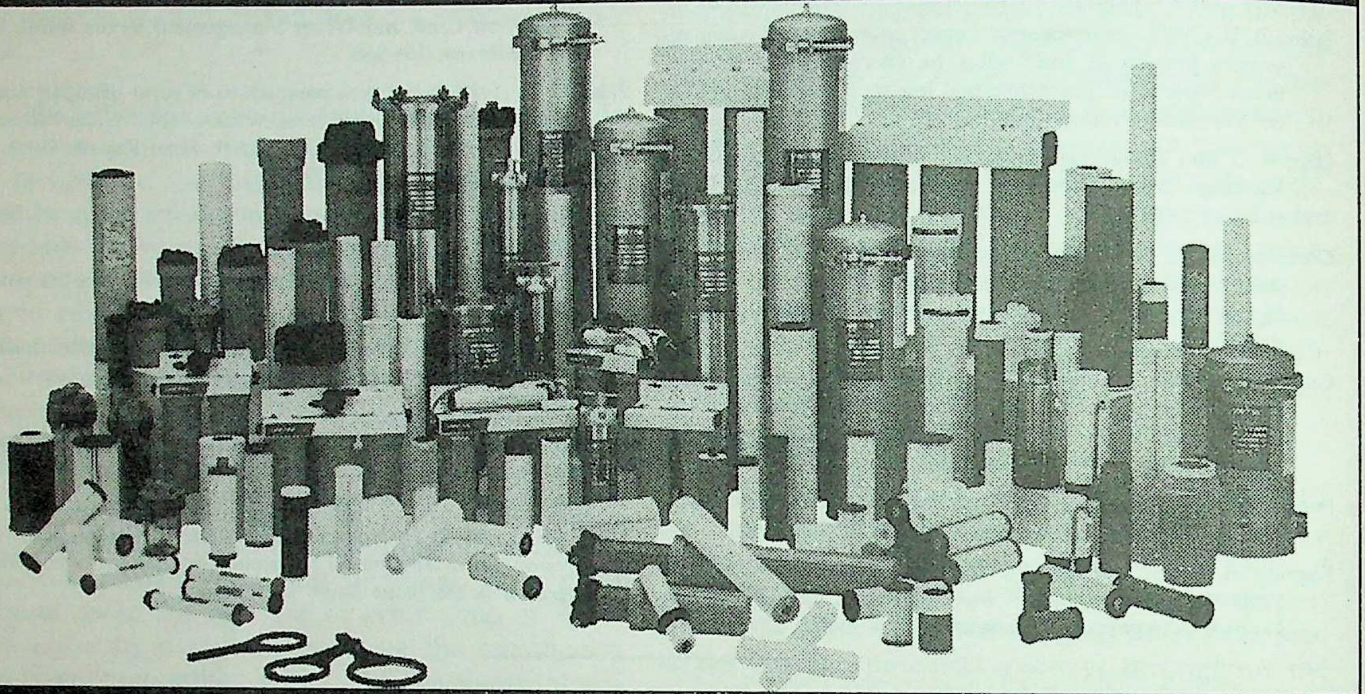

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Water Resource Development in Gujarat : Research Needs

S. K. Gupta*

1. Introduction :

Some time back Gupta and Sharma[1] wrote a rather provocative article entitled 'Should Israel Manage Gujarat's Water ?' The intention was to highlight the importance that indigenous innovative research and technology development in Israel received from the State compared to the dismal state of Indian R & D effort in this field. It is through harnessing of indigenous scientific talent that Israel has succeeded in developing its water resources to their present admirable state and in the process has emerged a world leader in water science in the last 3 decades. On the other hand, our failure to harness our water resources despite having spent enormously has led to a situation wherein water has emerged as the single most important constraint to economic development of Gujarat and much of India. In this article an attempt is made to identify research needs in the field of water science with a view to innovatively overcome the constraints of meteorology, geography and hydrogeology that limit natural availability of water in Gujarat. It is believed that some of these prescriptions will also be applicable in several other parts of India.

2. Water uses :

Water is required for (i) drinking and household uses; (ii) agriculture and animal husbandry and; (iii) industry. Water for drinking and household uses is of paramount importance; though the quantity required is small, the quality requirements are stringent. However, providing adequate water to other sectors is essential for sustenance, economic growth and improved quality of life. In the arid climate of Gujarat with highly seasonal rainfall, local harvesting of rainwater can, in principle, provide adequate drinking and household water supplies. The large requirements of agriculture and industry, however, necessitate developing and exploitation of large surface (the dams) and subsurface reservoirs (ground water). In terms of waste water, domestic biodegradable, non-toxic sewage accounts for nearly 90% by volume. The balance is largely accounted for by toxic industrial waste water, whereas irrigation for agriculture is a consumptive use.

3. The water crisis in Gujarat :

The whole of Gujarat, except some pockets, faces any of the following types of water crisis :

(i) There is an over all shortage of water of appropriate quality.

(ii) Most river courses around large towns and cities have, in effect, become drains for sewage and industrial effluents, causing pollution of surface and ground water. Sabarmati river, passing through Ahmedabad, is one of the fourteen most polluted rivers in the country.

(iii) Over-exploitation of ground water largely to meet agricultural requirements has led to a steady decline of water table between 3 m to as much as 50 m in different parts of the state. This has resulted in increased cost of pumping, abandoning of shallow wells and tubewells, shortage of drinking, agriculture and industrial water.

(iv) In intensely agricultural canal irrigated areas, we see logging, salinisation of soils, pollution of ground water due to use of chemical fertilisers and pesticides.

(v) The coastal aquifers are facing large scale sea water intrusion.

(vi) Fluoride concentration has been increasing in ground water in large parts of the state during the last 2-3 decades leading to increased incidence of fluorosis both in human and cattle population.

(vii) Inadequate sanitation and waste water disposal is leading to increased incidence of malaria, philaria, falciparum and several water borne diseases.

4. The constraints :

As in any other field, solutions to water crisis can come only through a proper understanding of natural constraints and innovative application of science and technology. We all know that rain, the only renewable source of water, partitions into three components after falling on the ground, namely (i) the surface runoff flowing in rivers and to a small extent accumulating in ponds and lakes, (ii) the soil and ground water, and (iii) the evaporation and transpiration. Of these, the last represents the consumptively lost/used component. There is, therefore, need to develop technology to reduce it at every stage possible. Certain minimum quantity of water must be maintained in lakes and rivers both for environmental and aesthetic reasons. During the last 5 decades since independence, large number of small, medium and large sized surface reservoirs have been constructed all over Gujarat State to meet increasing water needs. Harnessing of Narmada river flows through construction of two major dams — the Sardar Sarovar in Gujarat and Narmada Sagar in Madhya Pradesh — is expected to provide the largest increase in surface water availability in Gujarat. A proposal for isolating a large part of the Gulf of Cambay and converting it into a large freshwater lake named Kalpasar, by construction of 64 km long dam to harness terminal flows of Narmada and other northern rivers of Gujarat is also under consideration. No one can deny the importance of harnessing all surface flows in our arid environment though questions of cost/benefit and environmental and rehabilitation problems have to be considered in a larger context which also must involve consideration of other alternatives at a given time.

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The last of the three components of the rainfall, namely the soil and ground water is indeed the largest resource. While the soil water is used by plants and trees and transpired annually, it is the ground water, the exploitation of which has provided the most significant and cost effective source of water supply during the last 3 decades. It represents a long term reserve that is relatively pollution-free. Its importance further lies in the fact that unlike in surface storage reservoirs there is little evaporation loss from ground water; it requires small financial outlays for development and has low gestation period and lastly, technology for exploitation is well known. It is for these reasons that largest increase in agricultural produce has occurred in ground water irrigated areas that too largely through private enterprise of individual farmers.

5. Movement and recharge of ground water:

We shall see in the following that through innovative manipulation of aquifers in conjunction with surface water most of our future needs of water can be adequately satisfied both in terms of quality and quantity. But, let us first recall a few basic facts about movement and recharge of ground water under natural conditions.

(i) Exploitation of ground water even from deeper, commonly believed confined aquifers, leads to vertical flow of water across the semi-permeable confining layers due to hydrostatic pressure differential created. Continued over-exploitation leads to induced recharge of ground water from available surface water. This is best exemplified by the disappearance of Sabarmati river as it approaches Ahmedabad from north. The lean season flow of the river at Ahmedabad that used to be > 150 mgd in 50's dwindled to a trickle in 70's even before controlled releases from Dharoi reservoir could affect the Sabarmati river flow.

(ii) Studies using radioactive tritium isotopes as tracer of soil water movement indicated that in most parts of Gujarat vertical recharge of ground water from rain averaged 10-15%. Only in some areas in the foreland of Aravallis in north-west is the rainwater recharge about 20-25%.

(iii) In the alluvial areas deeper aquifers are extensive but rates of natural ground water flow in the horizontal direction are of the order of 10-100 m/yr. As a result deep ground waters are several thousand years old in age, i.e., they represent a reserve accumulated over thousands of years.

(iv) As a result of over-exploitation in nearly all parts of Gujarat, we have inadvertently created an underground void that is almost 10 times the total reservoir capacity of Narmada Project, both Gujarat and Madhya Pradesh included. Geographically, this reservoir space is more where relatively larger use of water takes place, for example in districts of Ahmedabad, Mehsana, Sabarkantha.

6. Conceptual framework of a viable water resource development policy:

If we now keep the geographical and geohydrological constraints in view and further think in terms of the growing population, changing life styles, needs of agriculture and industry, and try to evolve a strategy of providing adequate quantity of water of required quality appropriate for the intended use, the only option left is to adopt an approach that involves the three key words of conservation, renovation and reuse.

The proposed new approach to water resource management requires that all water sources of a region, namely surface flows, ground water, storm runoff and waste water be treated as components of a single system. These should be developed to meet quantity and quality requirements of each sector through technologies aimed at conservation through increase in application/use efficiency and reuse of renovated waste water whereever possible. If implemented properly, sanitation and environmental improvements will also be ensured.

In the following are listed some of the unexplored/not fully exploited ideas that need further research to advance the proposed conservation, renovation and reuse approach.

6.1 *Artificial Ground Water Recharge:*

We have already seen that exploitation of ground water provided the largest increase in water supply during the last three decades. It is, therefore, not unreasonable to expect that *if* we can (i) find surplus water and (ii) learn to rapidly effect the recharge of the same to the depleted aquifers in a cost effective manner, without endangering the purity of the subsurface regime, we would be in an advantageous position to solve the present water crisis. However, the two *ifs* listed above are our major constraints and we must understand their nature.

(i) The only source of surplus water in the arid/semi-arid environment of Gujarat is: (a) domestic and industrial effluents, and (b) storm water available during short but intense spells of heavy rainfall.

The domestic waste water is a year round assured source of reasonably consistent quality. On an yearly basis, the waste water generation in some regions (e.g., Ahmedabad) may be several times more than the total rainfall. Therefore, it should be treated to a level required for the intended use. To the extent waste water is directly reused after the necessary treatment, it helps conserve the source of new water. Conventional technologies are available, though there is a considerable scope for innovative technologies of waste water renovation and its recharge into aquifers through research[2]. The cost and environmental considerations related to disposal of residual solid waste are two important factors that also need to be considered.

Storm water is usually available in huge quantities in short spells. Some part of it is, no doubt, stored in dams, lakes, ponds and other available surface reservoirs, but a very large fraction still runs off because of unavailable surface storage space. However, if we could develop safe and effective methods of rapidly recharging the underground aquifers using the storm water, a substantial increase in water supply for all uses should be possible. The storm runoff is generally low in total dissolved salts, but the other undesirable constituents, in particular, nitrates, phosphates, pesticides, petroleum products, chemical industry and domestic effluents may adversely affect the quality of ground water.

(ii) Whether we use the renovated waste water or the storm water for ground water recharge, the potential for polluting the subsurface environment is fairly high because *inter alia* our objective in an artificial ground water recharge scheme is to accelerate the transfer of surface water to the subsurface bypassing the upper soil layers. These layers normally retard the natural infiltration of water in the process acting as an active filter medium to remove pollutants from the infiltrating water. Therefore, effective and safe technology for artificial ground water recharge requires inputs from (i) hydrogeology; (ii) hydraulics and (iii) contaminant transport in the subsurface systems — an emerging area of research in earth sciences. An understanding of how individual contaminants move in the subsurface is needed to evaluate probability of their reaching an aquifer and the extent of ground water contamination likely to occur. This knowledge is also required to develop and evaluate methods for using soil and aquifer as treatment/renovation media for low level waste water/storm water in certain selected regions. In order to devise technologies for safe disposal of toxic waste and for ensuring the quality of different water sources that can and will be developed through aquifer manipulation, we need to quantify the rates of advection (or convection), dispersion, inter-phase mass transfer (e.g., sorption, liquid-liquid partitioning and volatilisation) and reaction (e.g., bio-transformation and hydrolysis) governing the fate of contaminants during transport through porous media.

Many of the basic studies into understanding contaminant transport in the sub-surface environment will take a long time to reach maturity. This, in view of increasing use/misuse to which the subsurface environment is being subjected inadvertently, is perhaps the best reason to initiate these studies without further delay. Fortunately, these can form part of other projects that need to be undertaken even otherwise to advance the technology of artificial ground water recharge.

In the prevailing Indian situation with high population density, scarce land, seasonal rainfall and high potential evaporation, there is much to commend for construction and maintenance of tanks of all sizes depending on local topography for

(i) temporary (~10-15 days) surface storage of storm water and (ii) to link these with appropriately engineered percolation wells to enhance ground water recharge. In this manner, availability of safe drinking water can be ensured. Construction of tanks and percolation wells can be undertaken speedily with the help and involvement of beneficiaries. The outlays and gestation period required may not only be smaller compared to long distance pipeline supply, but a part of the cost can come from the direct beneficiaries. In over exploited regions such percolation wells linked to tanks can rejuvenate the dried shallow aquifers and the storage so developed can be used to provide fluoride free drinking water on a sustainable basis[3]. Development of local water resources through tanks linked to percolation wells affecting ground water recharge is also desirable as it reduces loss due to evaporation which is about 2 m of water column annually.

This approach is best illustrated by an example of the situation existing in Balisana village in Mehsana District, Gujarat. In this region, drinking water problem has become very acute due to high levels of fluoride (5-7 ppm) in ground waters. There is no river nearby in the area and the only renewable surface source of water is the village tank. The tank has an area of about 3 hectares with a mean depth of about 1.5 m and a catchment area of more than 5 km². The village has human population of about 12,000 and livestock population of 3,000. In this region the first shallow aquifer is located at a depth of 13-15 m and has a thickness of 3m. Presently water from deeper aquifers (>100 m) containing high levels of fluoride is used both for drinking as well as irrigation. The village Panchayat proposes to increase the storage capacity of the village tank by deepening it to an average depth of about 3 m. This will ensure a maximum storage, at the end of rainy season, of only 9×10^4 m³(= 3×10^4 m² x 3m) which is only one third of the annual water requirement. However with the construction of 15 percolation wells linked to this tank, we estimate that it will be possible to recharge 4 times as much water in about 100 days of a normal rainy season. In the post rainy season these recharge wells can be used for year round safe, fluoride free water supply. Clearly, without making use of the sub-surface reservoir space for storage of a large fraction of runoff, the villagers will benefit only marginally. This is because of evaporation losses from the surface storage as well as the limited storage of the tank which can supply only one third of the total water requirement.

The safety of the water resource so developed is likely to be ensured by the physico-chemical processes that operate during percolation through soil and traversal through aquifer (Soil Aquifer Treatment, SAT) in such a system. The SAT systems involve letting the raw or waste water percolate downwards to shallow aquifer through a ninimum of about 1m unsaturated soil zone and pumping or otherwise discharging the treated water after an average traversal of 100 m within the aquifer. The SAT systems can also be used for recycling of domestic waste water in housing societies and village communities, particularly if the small volume of dangerous toilet waste water is separated from the much larger volume of low level non sanitary waste and disposed of in suitably designed percolation wells that can also be used to dispose of storm water during the rainy season. Municipal waste water can also be treated through SAT system to a level better than the conventional secondary treatment at costs that may be as low as 60 percent. A pilot project based on the concept of SAT for renovation of municipal waste water in Ahmedabad is presently being experimented.

In urban areas storm water drainage is a serious problem. Construction of underground percolation wells as a means of holding the storm water temporarily and dissipating the same into shallow level aquifers needs to be developed as an effective alternative to the conventional storm water drainage systems[4]. A pilot project based on this concept will be initiated with the financial assistance of Ahmedabad Municipal Corporation.

The well recharging efforts of the farmers in Saurashtra in Gujarat need to be supplemented by well formulated studies on quantification of water recharged, and contaminant transport studies to ensure long term viability. We also need to develop technologies for storage and retrieval of surplus fresh water in brackish/saline aquifers that abound in Gujarat.

6.2 *Domestic systems :*

Recognition that all water uses even in homes do not require water of highest purity will go a long way in popularising the concept of renovation and reuse of waste water for household cleaning, toilets flushing and kitchen garden and horticultural uses. We need to make practical and convenient roof top rain water harvesting systems so that these will supplement the public source of water supply.

Further, through development of appropriate domestic waste water filtration/desalination systems (e.g. using reverse osmosis for conversion of brackish water into sweet water in the coastal areas of Saurashtra and inland areas like Bhal) the quality of drinking water can be ensured at little cost to the State.

6.3 *Water for Agriculture and Industry:*

Agriculture is by far the largest consumptive use of water. If India has been transformed from a begging bowl economy to a grain exporting economy in the last 2 decades, the credit really goes to irrigated agriculture with increasing input of chemical fertilisers and pesticides. In spite of tremendous gains made, a unit of agricultural produce in India consumes 5-10 times more water than in Israel. There is, therefore, very large scope for conserving irrigation water even while continuing to increase farm productivity. Low cost gravity flow systems are slowly giving way to energy and capital intensive sprinklers, trickle and sub surface irrigation systems. The technology is known, but its adoption is constrained largely by socio-economic considerations. Therefore, beyond emphasising the scope of large water savings and the possibility of large scale use of renovated waste water both of domestic as well as of certain industrial origin in agriculture, I do not propose to discuss this here any further.

Industry is another major user of water, but also generates large amount of waste water. Industrial processes in India are known to use several time more water than their counterparts in developed countries. As in agriculture, improving application efficiency, therefore, needs to be high on agenda. Cost of water is often an important input influencing application efficiency both in agriculture and industry. Large fraction of industrial waste water can be renovated and reused by industry and agriculture but some industrial waste waters are indeed very toxic and need to be very carefully disposed of. Further, residual solids (or concentrated liquid wastes) from renovation of industrial waste waters may also be highly toxic requiring complete isolation and disposal. In developed countries technology has been developed for deep underground disposal of toxic industrial waste products particularly in abandoned/non-producing oil-bearing reservoirs. As Industrial production and the associated need to isolate toxic wastes increase in the near future, there is urgent need to develop indigenous technical expertise now when the lead time is available.

7. **Infrastructure Requirements:**

What has been said in the foregoing, does not mean that there is no room for mega projects like Narmada and Kalpasar. These are required not so much for meeting domestic water needs, which are small and can be met through development of local water resources as explained above, but to meet large requirements of agriculture and industry.

But here also innovation has a role to play. In Kalpasar[5] project, for example, use can be made of the physical principle which allows lighter river run off to float over the denser sea water if the dam structure is left open from the bottom. The efficacy of this innovative modification of the dam needs to be established through computer simulation studies involving estimation of mixing across the fresh water/sea water interface. Such a study can be done at a fraction of the cost of the project. Irrespective of the viability or otherwise of the proposed modification being proved, the study should help understand the mixing and dilution of water in the lake to be created.

The required research and development of technologies can be done only if we have an appropriate infrastructure for innovative experimentation, monitoring, documentation and dissemination of the successful techniques.

Although there are many individuals, governmental agencies and voluntary organisations which are involved in several aspects of water conservation and renovation in a piecemeal manner, their impact is not being felt. The main reason is not so much the scarcity of financial resources but, it is the lack of application of scientific methods and effective monitoring of the impact of their studies. In the absence of proper infrastructure to undertake innovative research and development, the societal response will always be at a sub-critical level rendering it virtually ineffective.

The need, therefore, is to develop an Institute with a clear-cut mandate to undertake research and development in the field of water conservation, renovation and reuse.

References:

1. Gupta, S. K. and Sharma, P., *Curr. Sci.*, 1995, **68**, 582-584.
2. Gupta, S. K., *in Proc. TRF Seminar on Ahmedabad 2001*, 1988, **10**, Times Research Foundation.
3. Gupta, S. K. and Sharma, P., *Curr. Sci.*, 1995, **68**, 774.
4. Gupta, S. K., Sharma, P. and Shah, Mayur, *V. D. Tank Memorial Lecture*, 1995, Indian Water Works Association, Ahmedabad Chapter,
5. Gupta, S. K. and Sharma, P., *Curr. Sci.*, 1995, **69**, 227-228.

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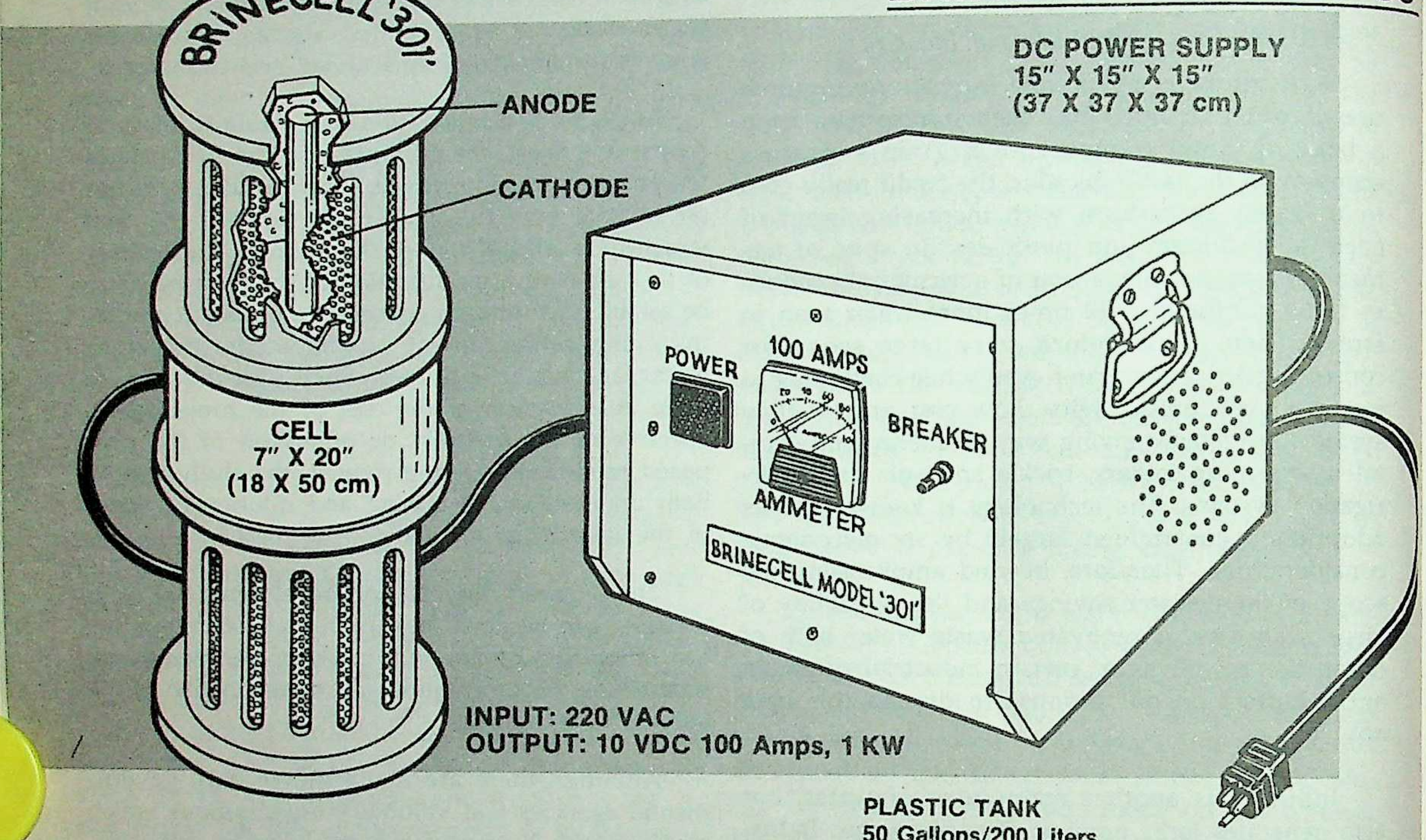
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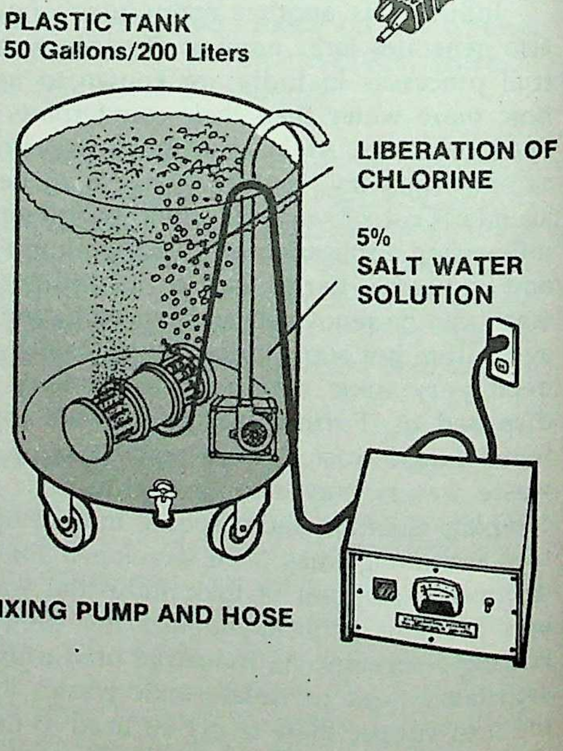
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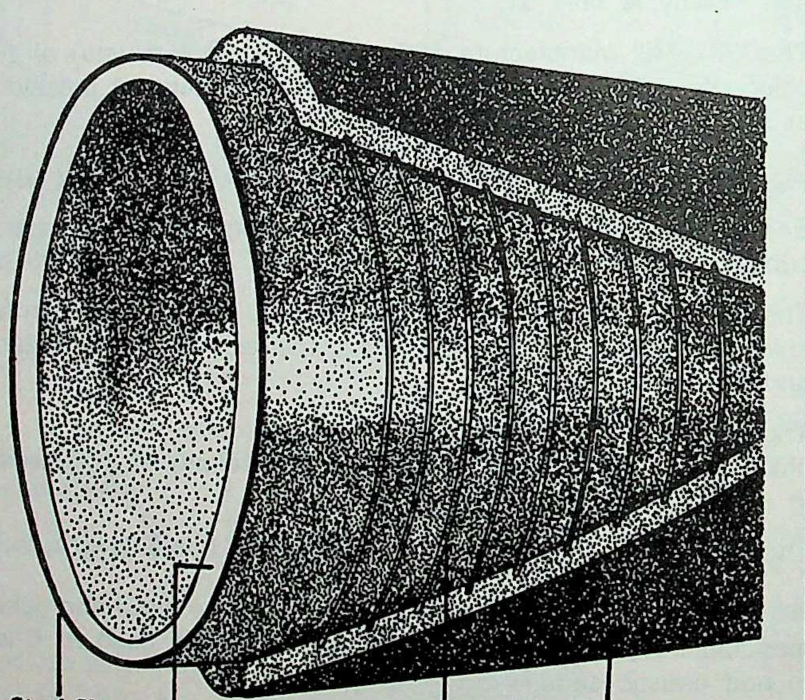

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Demand and willingness to pay for urban water and sanitation services in Baroda

Chetan Vaidya*

Introduction :

The issue of appropriate pricing and cost recovery from water supply and sanitation service has become very important. A major concern within this area of study relates to an understanding willingness to pay (WTP) for these services. The past policies for pricing of water and investment planning often do not capture willingness to pay for water services. Recent methodological developments use contingent valuation methods and measure compensating investments to assess WTP for such services. This paper has presented summary of a WTP study for water and sanitation in Baroda.

Baroda city had a population of one million in 1991. Baroda Municipal Corporation (BMC) is implementing a Rs. 66 crores water supply improvement scheme to raise the (1993) supply of 173 MLD to 285 MLD by 1997. HUDCO has sanctioned a loan worth Rs. 47 crores for this scheme. BMC has suggested revisions in tariff rates of water so as to cut down the level of annual subsidies which amounted to Rs. 1.08 per 1000 litres or 47% of the expenditure incurred on it in the year 1992-93. However, it is necessary to ascertain effectiveness of these rates. In this background this study of demand and willingness to pay for water and sanitation has been carried out.

Methodology :

The research team used both indirect (revealed preference) and direct (contingent valuation) methods to analyse how households make their choices about water and sanitation services. The indirect method used the revealed preferences of households through the actual choices and investments made by households in situations where no piped water is available and in others where it is not adequate. It will cover aspects related to nature of capital investments made and the operation and maintenance costs incurred by the households and/or communities.

Contingent Valuation method was used to estimate for Willingness to Pay based on the current levels and preferences identified, hypothetical choices and related price ranges were worked out for each major user category.

A survey of 550 households from different zones and types of housing was carried out. Detailed survey of 200 households among the sampled households was carried out for estimating WTP. In addition, case studies of different user groups were conducted. For estimating demand from industrial sector, survey of 40 units was carried out.

Water Supply Project :

Baroda city derives water from four sources which is equal to 173 MLD. Per capita supply has decreased from 158 litres per day in 1981 to 170 lpd in 1991. The water is supplied for domestic, commercial and industrial purposes. Non-domestic supply accounts for nearly 25 per cent of the total supply. Subsidy in water supply is estimated to be about 47% in 1992-93.

Baroda Municipal Corporation is presently engaged in water augmentation scheme. The original estimate of the scheme is Rs. 66 crores. BMC is planning to take up a water network improvement scheme of Rs. 10 crores and sewerage improvement system scheme. With augmentation of the water supply system, total quantity of water produced will increase from 173 to 285 MLD by the year 1996-97. Total current expenditure is estimated to increase by Rs. 20 crores. This includes increase in loan charges by about Rs. 8 crores per year. Therefore, during the process of sanctioning the loan, HUDCO has insisted upon revision in water tariff.

The percentage revisions of water charges suggested by Baroda Municipal Corporation vary from 10 to 90 per cent for domestic sector and for non-domestic sector, they range from 10 to 70 per cent. Assessment of revision of charges reveals that even with the revision, the level of cost recovery for water sector ranges between 36 to 53 per cent. If the Corporation wants to achieve self-sufficiency in water sector, then charges will have to be revised nearly 165 per cent in addition to already proposed charges (Mehta and Satyanarayan, 1993).

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Study sponsored as part of Research Cycle by HSMI, HUDCO, New Delhi, 1994.

As there is need for increasing water charges, it was felt necessary to assess the willingness to pay for different groups particularly industrial and domestic users. The domestic demand has to be assessed for new connections and monthly water charges. Implications of the study findings are given here.

Industrial Sector:

Water demand for industrial sector has been separately analysed for large and small/medium sized units. The survey of large scale industries shows that most industries cannot afford to rely solely on BMC water supply (Klink, 1992). The results of the survey reveal the following things. Operation and maintenance costs are a substantial part of total average cost of non-municipal water supply. Industries using tubewell water as standby have average costs higher than BMC, considering quality of tubewell water. Minimum cost rules are not the only factor in these investment decisions. Benefits of having an own supply system given unreliable municipal supply play an important role. They have their own stand-by system of tube wells which is of course costly but reliable.

TABLE 1

Distribution of households by source of water — Baroda

Source	% of HH	No. of households
1. Municipal house connection		
(a) Individual	18.9	39700
(b) Shared	7.0	14700
(c) Individual/shared with handpump/pump/underground storage	29.4	61700
Sub-total (1)	55.3	116100
2. Bore/tubewell		
(a) Individual/shared municipal and bore	16.0	33600
(b) Private/shared bore	3.0	6300
Sub-total (2)	19.0	39900
3. Public source		
(a) Individual/shared municipal with public sources	12.9	27000
(b) Public handpump/standpost	12.9	27000
Sub-total (3)	25.8	54000
Total	100.0	210000
House connection (1+2a+3b)	84.2	176700

Many of the small and medium industries have also made investment in private sources (70%). They need additional municipal water; however, are not willing to pay more than present charge of water. Therefore, BMC may not be able to cross-subsidise domestic users beyond a certain limit.

Domestic Water Situation:

(a) *Source:* Conventional method of analysing sources of water as individual house connection, public taps, tubewell/bore does not indicate the true situation. Households are using a combination of methods to obtain water. Existing sources of water supply reflect water supply situation. Therefore, special code was developed for source of water supply. Distribution of households by source of water is given in Table 1. It reveals that though 176 thousand households have access to house connection only 40 thousand use it exclusively.

About 15 thousand have to share it with other households. Other 62 thousand have to use handpump, pump and underground storage to use water from house connection. As many as 60 thousand households with house connection have to supplement this supply with bore or public sources.

(b) Water supply from all sources is estimated to be 95 lpcd and 71% of it is from house connection. Only 18% of the total households are satisfied with existing level of municipal supply.

(c) Every third household in the city has to spend time for collection of water. As many as 70 thousand households in the city, on an average, spend one hour per day for water collection. Most of this time is spent by women and children. Opportunity cost of this time at Re. one per hour is estimated to be Rs. 2.6 crores per year.

Expenditure:

(a) Expenditure on water has been assessed in terms of municipal and non-municipal payment. About 70% of households are paying water charges. Annual payment to the corporation is Rs. 102 per household.

(b) About 49% of households have made capital expenditure on bore, filter, pump, underground storage, etc. Average non-municipal expenditure is Rs. 1345 per household. Total non-municipal expenditure in the city is calculated to be Rs. 28 crores. It is about 40% of original cost of the water supply augmentation scheme.

TABLE 2

Annual expenditure on water supply — Baroda

Type	Per household* (Rs.)	All households (Rs. in crores)	% expenditure to HH income
(a) Municipal	102	2.14	0.26
(b) Non-municipal	437	9.18	1.10
Total	539	11.32	1.36

* Capital cost annualised at 15% interest with 10 years repayment.
Per household cost among all households.

(c) Annual expenditure has been estimated under certain assumptions (Table 2). Total annual expenditure for all households of the city is Rs. 11.3 crores and out of it only 19% made to the municipal corporation. Implicit rate for municipal and non-municipal water supply works out to be Rs. 3.0 per 1000 litres which is two times the municipal rate (Rs. 1.5 per 1000 litres).

(d) Annual expenditure as percentage of household income is calculated to be 1.36. It is only 0.26% for municipal expenditure. It is not surprising that 65% of households have expressed that municipal corporation should charge for water supply. Monthly electric charge is Rs. 160 per month per HH which is 4.5% of the income.

WTP for water:

(a) Households without house connection account for 16% of total households. About 85% of them have expressed Willingness To Pay (WTP) for improved standpost and average monthly payment works out to be Rs. 7.5 per household.

(b) Among households with house connection, 63% are willing to pay for better pressure and corresponding figure for improved quality is 11%. Average monthly WTP for improved pressure is Rs. 25 per household which is about 3 times the present rate. Improved pressure alone could bring an additional income of Rs. 2.26 per year.

TABLE 3

WTP for water as percentage of income — Baroda

HH income group (Rs.)	No. of households	Annual WTP (Rs./HH)	% WTP to HH income	WTP to average WTP (in each class)
Upto 1500	35700	275	1.90	0.81
1501-3000	81900	340	1.26	1.00
3001-4500	39900	326	0.72	0.96
4501-6000	33600	363	0.58	1.07
6000+	18900	439	0.49	1.30
	210000	339	0.85	1.00

(c) Households with house connection were asked how they will respond if monthly water charge is increased without any increase in the supply level. As many as 79% of the households have expressed that they would continue to use house connection if monthly charge is increased from present Rs. 8 to 25 per household. Perhaps it reveals that the households have the affordability to pay much higher water charge than present level.

(d) About 58% of households are WTP one time connection charge. Average connection charge is Rs. 726 per HH (among households who are willing to pay). Total capital revenue from these connections will be Rs. 8.8 crores. Little over 95% households have expressed WTP monthly charge of Rs. 23.9 per HH. Annual water charges are estimated to be Rs. 5.8 crores.

(e) Annual WTP amount per household has been estimated as 15% interest on capital charge plus annual maintenance charge. It is calculated as Rs. 339 per household (among all households). Households are willing to pay 3.4 times of present municipal expenditure. However, expressed WTP is only 60% of present expenditure on water. Total revenue from water supply will be Rs. 7.11 crores per year.

(f) Annual WTP is 0.85% of household income (Table 3). It decreases with rise in income. It is for the lowest income group (below Rs. 1500) and the corresponding figure for the highest income group (above Rs. 6000) is 0.49%. WTP for the highest income group is Rs. 439 and it is only 1.6 times WTP for the lowest income group (Rs. 275). There is limited scope for cross-subsidy among different income groups.

(g) In spite of the fact that expressed WTP is more than three times the present municipal payment, domestic sector alone will not be able to meet the current expenditure due to increase in loan and O & M changes (Table 4).

TABLE 4

Current expenditure and revenue for water supply sector in Baroda — 1996-97

Annual current	Amount (Rs. in crores)
(a) Expenditure	33.49
(b) Revenue from domestic sector*	8.45
(c) Net Gap	24.94

* Assuming increase in number of households by 2.4% per year and WTP to increase by 20%.

(h) *Role of neighbourhood groups:*

A large number of community based systems are operating in the city. These include community managed distribution of municipal water among different flat owners in GHB colony, management of common bore in unauthorised low income colony, and payment for public standposts in slum areas. A community based low cost infrastructure financing association is also working in the low income area.

Many community based systems have been observed in low income areas. However, in some high income areas, neighbourhood groups have not been able to help themselves. These high income groups continue to have low level of municipal services. It is felt that neighbour groups play an important role in obtaining municipal services in different areas.

Sanitation:

(a) A very large proportion of households has access to sewered connection (63%). About 14% use toilets with septic tanks/soak pits. Another 6% have no facility. As many as 73% of the households are satisfied with existing system. Thus unlike water supply, sewerage service is not perceived as a major problem. Annual expenditure on sanitation is Rs. 136 per household and only 26% of it is on non-municipal aspects such as septic tank/soak pits.

(b) As a large proportion of households are satisfied with existing sewerage system, only 27% want to pay connection charges. Average charge per household is Rs. 161 (among all households).

(c) Annual WTP for sanitation is Rs. 144 per household. Total annual payment is estimated to be Rs. 3.0 crores. It reveals that major sewerage improvement schemes cannot be taken up with huge subsidies. Therefore, it will be necessary to combine water and sanitation charges. Monthly WTP for the two sectors is Rs. 40 per HH. The WTP as percentage of income is 1.21%. It ranges between 0.72 to 2.7% and decreases with rise in household income.

Recommendations:

The principle of full cost recovery is in consonance with the new economic policy. Households are also willing to pay. For sustainability of the water supply system, BMC should accept the principle of full cost recovery and achieve it gradually over the next few years. These are also recommendations of the recent Working Group on Financial Issues and Cost Recovery, set up by Ministry of Urban Development, Government of India.

Strategy to improve cost recovery in water supply and sanitation sector in Baroda is presented in Tables 5 and 6.

Specific recommendations are:

(a) *Increase local knowledge about cost of the services:*

There is need to carry out an awareness programme to increase local knowledge about cost of municipal and non-municipal water and sanitation. Information should be provided regarding efforts made by women in collection of water, benefits of the two basic services and indirect environmental cost of using ground water resources.

(b) *Launch campaign on improved water supply at appropriate prices:*

A campaign should be launched for consciousness-raising and mobilisation on the theme of 'improved water supply at appropriate price'. Linking of service improvement with increase in the prices will help in raising public support.

(c) *Raise water charges:*

Minimum water tax/charges should be gradually raised from existing Rs. 7.50 per month to Rs. 25 per month. Concept of minimum charge should also be introduced for sewerage tax. Connection charge for domestic water and sewerage is to be raised from existing Rs. 250 to Rs. 750 and Rs. 1000 respectively. However, life line supply should be provided to the urban poor.

TABLE 5

Strategy for water supply — Baroda

Category	No. of households	Strategy
(A) Households without house connections (HC)		
(i) WTP for HC	23000	Encourage new connection. Group loan for connection charge.
(ii) Low WTP for HC	11000	Improved standposts with payment
(B) Households with house connection		
(i) Water problems and WTP	134000	Improved pressure and quantity of supply
(ii) Less waer problems and low WTP	42000	Awareness programmes for increased water charges

(d) *Integrate water and sanitation charge :*

Water supply and sanitation charges should be integrated to increase cost recovery.

(e) *Shift distribution to local groups :*

Responsibility of distributing water and sanitation services should be shifted to local groups. The aim should be to encourage these groups to take the responsibility with a view to enhance management. The groups could be made responsible for collection of charges.

(f) *Involve ward committees :*

As per the new 74th Constitutional Amendment bill (Nagarpalika bill), committees will be formed in different wards. Members of these committees should be involved in this programme.

TABLE 6

Strategy for Sanitation — Baroda

Category	No. of households	Strategy
(A) Households without sewerage system		
(i) Low WTP for improvement	21000	Low cost sanitation with loan facility
(ii) WTP for improvement	57000	Encourage new connections. Group loans if necessary.
(B) Households with sewerage connection and Low WTP	142000	Awareness programme for increased charges. Linkages with water charges.

(g) *Regularise unauthorised connections, and obtain revenue from them :*

Many development authorities and urban local bodies have launched the programme for regularising unauthorised residential colonies. Similar programme should be introduced for regularising unauthorised water and sanitation connections.

(h) *Simplify procedures :*

Existing time consuming and cumbersome procedure for new service connection should be simplified. Present system of providing individual house connections to authorised residents should be changed. GEB provides electric connections to households in unauthorised low income areas and similar approach could be adopted for water and sewerage system.

(i) *Need to Market water and sanitation :*

There is need to involve marketing experts to convince policy makers and communities of the advances of improved sanitation and water supply. Political support will be required to achieved these objectives. Marketing of the services could also create a demand for these services at the community group level. Once there is a demand, private enterprise will seize the opportunity. Licensed plumbers should be involved in the market programme.

(j) *Support community based infrastructure finance system :*

A community based infrastructure finance system is operating in selected low income areas of the city. This system should be replicated in other areas and supported by the financing agencies.

(k) *Delink service taxes from ARV :*

At present, service taxes are based on Annual Rateable Value (ARV) of the properties. This ARV often does not reflect market rent due to associated problems of Rent Control Act. It is necessary to delink service taxes from ARV. The service charge should be based on floor area, use and zone. General tax may continue to be based on ARV.

Conclusion :

Total investment in public issues of companies in Baroda during 1993-94 was about Rs. 300 crores. It was 2.3% of total investment in the country. They have the affordability and WTP to pay for improved water supply. Issue is how to capture this WTP in terms of the cost recovery. A campaign should be launched in the city with the theme of 'Improved Water Supply at Appropriate Price'. This should be followed up with improvement in supply, increase in water charges, simplification of procedures, etc.

References :

Altaf, M. A., Jamal, H. and Whittington, D. (1993), 'Rethinking Rural Water Supply Policy in Punjab, Pakistan' Water Resources Research, Vol. 29 No. 7, pp 1943-1954.

Bell, M., Joh, B. and Others (forthcoming), 'Reliability of Urban Water Supply in Developing Countries — The Emperor has no clothes' World Bank Research Observer (World Development Report, 1994).

Joshi, R. (1990), 'Augmenting Capital Resources for Urban Development — Case Study of Baroda Municipal Corporation', Ph.D. Thesis, M.S.U., Baroda.

Klink, J. and Sharma, S. (1992), 'Appraisal of Water Supply Project — Case Study of Baroda', HSMI, HUDCO, New Delhi.

Rodell, M. J. (1992), 'Appraisal of Local Govt. Financial Capability and Cost Recovery of Water Supply Projects — Baroda' HSMI, HUDCO, New Delhi.

Singh, B., Ramasubban, R. (1990), 'Rural Water Supply in Kerala, India — How to Emerge from a Low Level Equilibrium Trap', Water Resources Research, Vol. 29 No. 7 pp 1931-1942.

Whittington, D. and Laurai, D. L. (1993), 'Household demand for improved sanitation services in Kumsai, Ghana — A Contingent Valuation Study' Water Resources Research 29(6), pp 1539-1560.

World Bank Water Demand Research Team (1993), 'Demand for Water in Rural Areas — Determinants and Policy Implication', World Bank Research Observer, Vol. 8, No. 1, pp 47-70.

Whittington, D. and Laurai, X. (1991), 'A Study of Water Vending and Willingness to Pay for Water in Onitsha, Nigeria', World Development, Volume 19, No. 2, pp 179-198.

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Flood Management in India with special reference to eastern Uttar Pradesh

Ramanand Yadav*, Dr. Pande B. B. Lal*

Synopsis :

Eastern U.P. has 29.2% geographical area of U.P. but has 44% flood prone area of the State and the total loss due to flood damage is as high as 60% of the State losses. The disastrous flood situation can be seen in the area near Kauriram town and Rapti-Gurra Doab in Gorakhpur district. Nearly 20,170 ha land remains flooded 1 to 5 weeks under 2 to 3m depth of water in monsoon season. The inhabitants of this vast area are completely marooned and face a lot of problems. This paper deals in detail with the flood problem and damages of eastern U.P. with flood zone and the nature of problems of the region. Past efforts of flood control and remedial measures suggested have been highlighted.

1. Eastern Uttar Pradesh :

Eastern Uttar Pradesh (latitude 23°50′N to 28°45′N; longitude 80°57′E to 84°50′E), basically a backward region, is one of the largest zones of Uttar Pradesh, and situated on the foothills of Himalayan ranges in the middle of the Ganga basin. It comprises 21 districts (Fig. 1) and covers an area of about 85,844 sq.km which is nearly 29.2% of geographical area of Uttar Pradesh. The study area is mostly situated between Ghaghra and Gandak river systems. Important rivers Ganga, Ghaghra, Rapti, Rohin, Burhi Rapti, Ami, Kuwano, Gurra, Tons, Kunhra, Ghonghi, Great Gandak, Little Gandak, Taraina Nala etc. flow in this region.

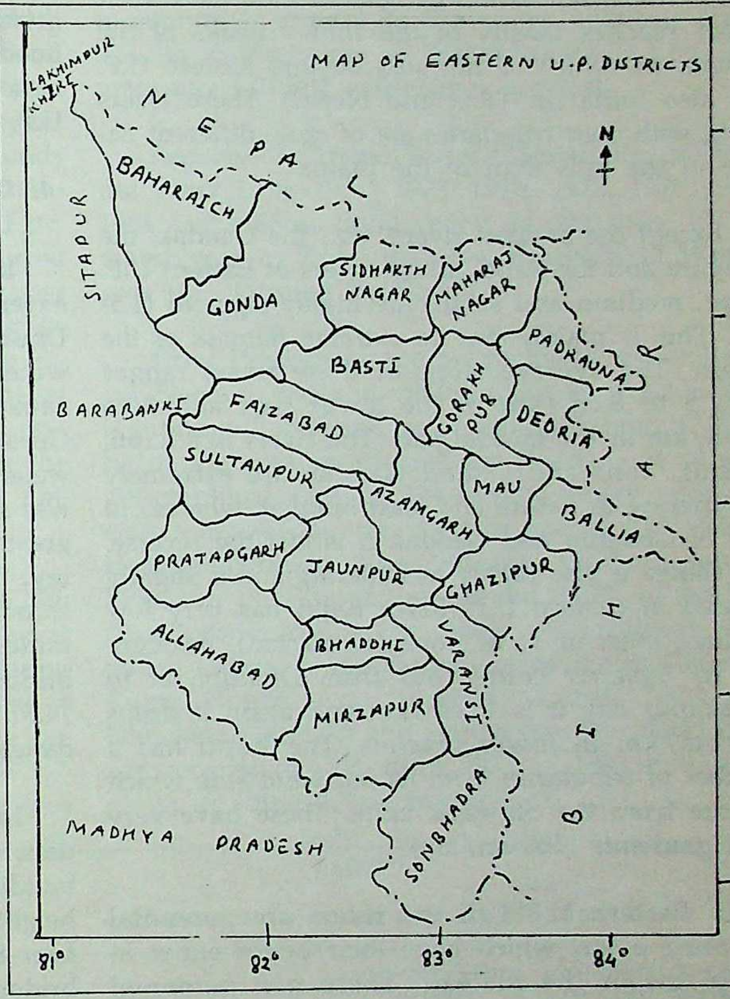
MAP OF EASTERN U.P. DISTRICTS
LAKHIMPUR KHERI
N E P A L
N
28°
BAHARAICH
SITAPUR
SIDHARTH NAGAR
MAHARAJ NAGAR
GONDA
27°
PADRAUNA
BASTI
GORAKH PUR
DEORIA
BARABANKI
FAIZABAD
SULTANPUR
AZAMGARH
MAU
BALLIA
26°
PRATAPGARH
JAUNPUR
GHAZIPUR
B I H A R
ALLAHABAD
BHADOHI
VARANSI
25°
MIRZAPUR
SONBHADRA
MADHYA PRADESH
24°
81°
82°
83°
84°

Fig. 1

Eastern U.P. can be divided into three zones on the basis of hills, plains and plateau :

(i) North zone which is a part of foot hills of the Himalayas (i.e. the Siwalik and Bhabhar) cover 5% area of the eastern U.P.

(ii) Tarai Zone which is a part of Ganga Alluvial Plain covers 88% of the region and is almost a homogeneous plain.

(iii) Vindhyan Plateau covering 7% area of the region.

2. Climate and Rainfall :

The region experiences three different seasons in a year. The Cold Weather Season (November to February), the Hot Weather Season (March to June) and the Rainy Season (June to October).

The average rainfall in eastern U.P. is about 100 cm and about 70 to 80 cm rainfall is concentrated in rainy season alone. The region may be divided into three rainfall zones viz. (i) high (Tarai zone), (ii) medium (eastern and Southern part) and (iii) low (Central and West-Central part). In Eastern U.P., the rainfall decreases from East to West and from North to Centre of the region and again increases in the South i.e. the plateau region. The high rainfall towards the North, East and South is due to the proximity of the Himalayas, the Bay of Bengals's monsoon current and higher relief of plateau respectively. The rainfall is very much uneven and erratic.

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3. General river characteristics :

The rivers of eastern U.P. are of various nature. This variation is found even within the same river course, because they flow through three different physiographic regions, viz. Hills, Plains and Plateaus. The major rivers of Eastern U.P. have their upper reaches mostly in the snowy peaks of the Himalayas, which lie not only beyond Eastern U.P. but also India (in Tibet and Nepal). These rivers along with their tributaries are of quite different nature in the hills than in the plains.

Except the braided rivers, viz., the Gandak, the Ghaghra and the Rapti, all the rivers of Eastern U.P. (large, medium and small) are highly sigmoid (1.5-2.5). This is mainly due to extreme flatness of the region. The average slope of these rivers ranges from 5 to 8 cm/km in the lower part and 8 to 12 cm/km in the middle part. The rivers like Rapti, Gomati, Tons and Chhoti Gandak are extremely meandering in nature and least braided, whereas in case of Ghaghra and Gandak it is just the reverse. The Ganga is also highly meandering and is slightly braided in eastern U.P. River Rapti has very low gradient even in Tarai Zone (12 cm/km), throughout its Easterly course but from Dhanibazar to Gorakhpur city it is 15 cm/km and again it drops to 8 cm/km in lower reaches. The Rapti has a number of tributaries from its left hand side which emerge from the Shiwalik zone. These have very high gradients (100 cm/km).

In Eastern U.P., all the rivers are perennial excepting a few which have their origin either in the plains or the plateau. These non perennial streams are found in the Ganga-Ghaghra Doab and South of the Ganga, whereas all the rivers issuing from the Himalayas are perennial. In Ghaghra-Rapti Doab some streams are of plain origin. Since all the rivers of Eastern U.P. receive about 80% of their water directly from monsoonal rainfall (S.W.), which is very much erratic in nature, therefore, range of minimum and maximum flow is extremely high. In case of Ganga the ratio of minimum and maximum flow is 1 : 63. The braided rivers carry huge volume of water mixed with high sediment load in comparison to non braided rivers.

All the rivers of Eastern U.P. bring huge amounts of sand, silt and clay, especially during rainy season and deposit it in their lower reaches of the flood plains. The braided rivers like Ghaghra and Gandak bring more sand than silt and clay, which makes the land infertile throughout their course; whereas the Ganga, Rapti and the Gomati bring fertile soils i.e. more silt, clay and organic matters. Appearance of big chunk of land at one of these rivers like Ghaghra and Gandak. Erosion and deposition, in case of meandering rivers, is also remarkable. While the small tributaries (brooklets) in Bhangar land continuously erode the surface giving rise to a bad land topography. Thus the flood situation in the study area is affected by the various characteristics of the rivers of the Eastern U.P. and its adjoining region.

4. General history of past floods in eastern Uttar Pradesh :

In 1823, a sudden rise in the Ghaghra caused extensive inundation over the Parganas of Dhuriapar and Chillupar in Gorakhpur district. The waters of the Rapti were held up and this river caused the same effect on Ami, so the city of Gorakhpur became an island with vast sheet of water around and the communication of Azamgarh was suspended for several days. In 1839, a flood of great magnitude was experienced in the Rapti valley. However, thereafter no further flood is chronicled till 1871. The flood of 1872 badly affected middle Ganga valley and recorded at Malaviya bridge (Varanasi) and Shastri bridge (Jaunpur) i.e. 74.51 m and 78.94 m against 71.26 m and 74.04 m danger levels respectively.

In 1873, also in 1889, the whole Gorakhpur district suffered extensive damage in fields and buildings. The Rapti rose on 4th August 1889 to a height of 77.20 m above m.s.l. at the railway bridge near Sahjanwa, while the Rohin at the Chilua Tal bridge was even higher. The height registered on the gauge at the Ilahi Bagh Sluice Gate in Gorakhpur city was 5.03 m. Three years later in 1892, the Rapti flooded the city and endangered the pontoon bridge at Bhauwapar, while in the same year in 1892 the Ghaghra ran very high from August 30th to September 4th. It was at full height in the vicinity of Dohrighat from September 2nd to September 4th, due to continued and heavy down pour during August and the beginning of September and for some time the town of Barhaj was surrounded with water. Another sudden flood of unusual magnitude occurred in 1903, when the water rose at the Rapti and Rohin bridges to 76.94 m and 76.71 m respectively. A still more destructive inundation was that of 1906, when the water rose to 77.27 m (Gazetteer of Gorakhpur District). No description of any flood is available from 1906 to 1937. The flood of 1938 was worst in the history (Bajpai & Misra, 1939). There was a continuous rainfall from July to September in the region. The provincial road between Gorakhpur to Lucknow was breached. Gandak river floods inundated large area in 1962.

In 1974, Rapti at Birdghat rose to a level of 76.84 m which was 1.86m above danger level and Gorakhpur town became an island. In 1978 which was a year of heavy floods as much as 74.17 lac ha and 23% of population were affected. Again in the years from 1980 to 1985 except for the year 1981, Eastern U.P. experienced very heavy floods due to incessant rains. In the year 1985 most rivers of the State such as Ganga, Ghaghra, Rapti etc. became turbulent. Unprecedented rainfall occurred in Gomti catchment on 14th and 15th September 1985 resulting in extensive water logging in Lucknow town. The cloud burst caused unprecedented rise in the levels of Gomti at a rate of 10 cm per hour (i.e. 2.40 m per day) against the previous maximum of about 0.60 m per day in the highest floods of 1960 and 1971 (Pande B. B. Lal, 1987).

Another spell of heavy rains occurred on 24th and 25th September 1985 causing Gomti to rise at Sultanpur by 4 m above danger level inundating vast areas. Unprecedented rainfall also occurred in Rohin catchment on 13th September 1986 in a period of 8 hours, resulting in inundation of 638 villages breaching three marginal bunds at six places and affecting about 67000 ha area besides other losses of property and lives. Unprecedented rainfall in Rae-Bareli and Sultanpur districts resulting again in inundation, loss of property and lives. The flood of 1989 was worst in the history of Gorakhpur when maximum discharge of 5346.50 cumecs flowed in Rapti at Birdghat. On 5-8-1989 corresponding gauge was registered 76.31 m which was 1.43 m above danger level.

The U.P. Flood Committee report mentions the years 1926, 1932, 1934, 1937, 1938, 1942, 1943, 1944, 1946, 1947, 1948, 1955, 1974, 1981, 1986 and 1989 as flood years of the region. The district Gazetteer of Gorakhpur describes the years 1938, 1974, 1981 and 1989 as worst flood years recorded in the history.

5. History of flood damages:

Floods are occurring in various parts of the country from time immemorial resulting in tremendous destruction and suffering to human lives, crops and property. An analysis of the data given in Table 1 for the period 1953-1988 evidences that more than 40 m ha i.e. one-eighth land of India is prone to floods out of total geographical area of about 329 m ha. The average annual damages (crops, houses and public utilities) in country is around Rs. 875 crores, affecting annually an average area of 7.90 m ha, while 1,517 human and 1,02,802 cattle lives are lost.

Reports of Central Water Commission mention the years 1955, 1971, 1973, 1976, 1977, 1978, 1980, 1984 and 1988 as flood years. Among them 1978 is worst year of flood disaster in which 17.53 m ha area was affected by floods.

Uttar Pradesh is one of the most severe flooding States in India in which about 73.36 lac ha area is prone to floods and on an average about 43.43 lac ha of the area is affected by floods, out of total geographical area of 294.4 lac ha every year and causes heavy disasters as reported by U.P. Irrigation Department. The National Commission on Floods in 1980 stated that around 23.2% of the total flood prone area in the country is located in U.P. which comes in the catchment of rivers Ghaghra, Rapti, Rohin, Ami, Sharda, Gomti, Tons, Sai, Narayani (Gandak) and Ganga etc. The flood damage records of U.P. from 1973 to 1991 have been given in Table 2 (see next page).

TABLE 1

Damages in India due to Floods

Sl. No.	Item	Average Annual damage (1953-1988)	Maximum in any one year during 1953-1988
1.	Area affected in m ha	7.90	18.60
2.	Population affected in million	30.90	70.40
3.	Damage to crops		
	(i) Area in m ha	3.69	10.00
	(ii) Value in million	Rs. 3,193.60	14,253.70
4.	Damage to house		
	(i) Number	11,59,647	3,50,76,542
	(ii) Value in million	Rs. 891.70	5.838.50
5.	Cattle lost (no)	1,02,807	6,18,248
6.	Human lives lost (no)	1,517	11,316
7.	Damages to Public Utilities million	Rs. 6,268.50	40,592.60

Source: Report of Central Water Commission (1990).

TABLE 2

Damages due to Floods in U.P. from 1979 to 1991

Year	Affected districts (no)	Affected population (lac)	Affected Villages (no)	Affected area (iac ha)	Affected culturable area (lac ha)	No. of damaged houses (lac)	Loss of Lives		Estimated Loss (Rs. crore)
							Human (no)	Cattle (no)	
1973	48	141.58	30,004	35.00	22.23	2.98	163	375	296.84
1974	39	73.90	14,948	19.86	12.24	2.03	72	160	173.16
1975	35	92.14	18,629	23.65	14.21	2.01	181	892	192.44
1976	36	131.95	32,962	33.49	18.34	2.05	240	1432	234.79
1977	31	37.80	7,536	12.87	6.42	0.51	157	887	77.04
1978	55	225.87	48,886	72.50	38.82	11.98	739	7430	688.47
1979	16	21.05	3,913	7.03	5.18	0.23	77	220	57.57
1980	46	303.47	44,629	58.57	30.94	19.23	1,309	5,244	790.67
1981	33	146.27	20,706	29.91	16.35	4.91	427	1,356	286.30
1982	44	232.91	32,459	55.38	33.09	10.18	562	2,517	585.05
1983	56	155.34	24,731	38.60	24.99	5.16	519	2,101	754.03
1984	39	65.75	11,600	16.68	10.31	0.83	209	432	262.15
1985	55	195.59	27,113	40.28	24.19	6.20	804	3,808	1,216.26
1986	45	59.41	8,925	10.34	6.45	0.51	223	725	278.64
1987	9	38.24	5,807	5.81	3.16	1.00	163	990	186.14
1988	46	194.13	24,721	31.77	17.14	3.71	765	2,101	834.60
1989	25	48.61	8,281	10.03	6.52	0.78	168	516	292.05
1990	51	88.76	16,074	22.08	12.04	1.51	492	3,028	542.57
1991	29	24.18	3,372	8.11	2.91	0.78	215	369	147.75

Source: Secretariat, U.P. Irrigation, Lucknow (1993).

6. Flood damages in Eastern U.P. :

Eastern U.P. which is only 29.2% of the area of U.P. alone has 35.1 lac ha (i.e. 44%) flood prone area of the State and the total flood loss is as high as 60% of the State losses. The average area liable to floods in Eastern U.P. is 21.2% as against only 14.6% of U.P. as a whole and the maximum flood prone area in Eastern U.P. is 30 lac ha which is 86% of the total flood prone area of the region. It indicates that flood frequency and flood intensity is also much higher than that of U.P.

Flood damage intensity is the highest in case of eastern U.P., if we consider the National and State averages. Flood havoc of this region annually draws the attention of both the State and Central Governments. In the Eastern U.P., there exists a wide range of spatio temporal variation in flood intensity and losses to various sectors, such as crops, houses, livestocks, man and public properties. River Rapti causes a lot of havoc in districts of Bahraich, Gonda, Basti, Siddharth Nagar and Deoria. It inundates as much as 3,50,000 ha land every year.

7. Flood zones in Eastern Uttar Pradesh :

On the basis of flood intensity, the whole region may be divided into three main flood zones, as shown in Fig. 2 (see opp. page).

1. High flood zone (Area flooded above 60%)
2. Medium flood zone (Area flooded 60% to 30%) and
3. Low flood zone (Area flooded below 30%).

7.1 *High Flood Zone :*

This high flood zone accounts for about 40% of the total area of Eastern U.P. and is found in two parts.

(a) Upper North-Western zone including districts of Bahraich, Faizabad, Gonda and Basti and (b) Lower Ganga-Ghaghra Doab (Ballia and Ghazipur). The North-Western high flood zone has high flood frequency and area, mainly due to proximity of the Himalayas and the lower zone mainly due to confluence effect of the major rivers like Ganga, Ghaghra and Gandak. The upper zone is affected by Ghaghra and Rapti whereas lower is affected by Ganga and Ghaghra directly. They affect this zone at different periods and sometimes simultaneously. The upper zone sometimes experiences flash floods also due to the proximity of the Himalayas.

7.2 *Medium Flood Zone :*

It covers about 33% of the total area of Eastern U.P. and flood intensity ranges from 60% to 30%. It includes the districts of Varanasi, Jaunpur, Azamgarh, Deoria, and Gorakhpur. This zone stretches from Northern Tarai region to the Southern upland. The Tarai parts of Deoria district in the North and Southern parts of this zone (i.e. parts of Chakia and Chandauli tahsils of Varanasi district) receive flash flood due to proximity of the Himalayas and rocky surface of the Southern upland respectively. Deoria district lying in the Tarai belt does not fall in high flood zone, because the run off of the upper reaches is diverted to either sides of the district (East and West) by Rapti and Gandak drainage systems which least affect the district. This medium flood zone is affected by all the major rivers i.e. Gandak, Ghaghra and Ganga and some of their tributaries such as Little Gandak, Choti Sarju, Gomti, Tons etc.

Flood zones in eastern U.P.

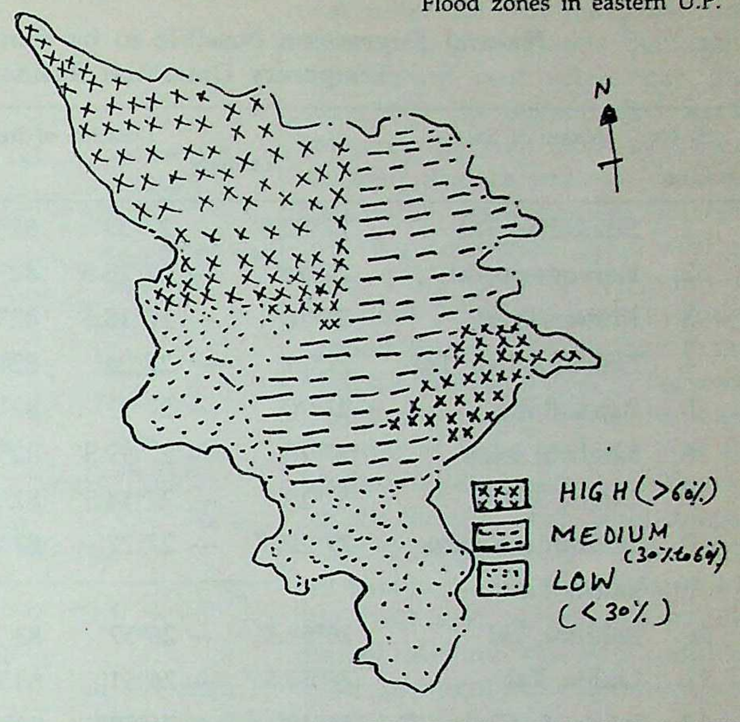


Fig. 2

7.3 *Low Flood Zone :*

This zone includes five districts namely Pratapgarh, Sultanpur, Allahabad, Mirzapur and Sonebhadra of Eastern U.P. It stretches in the South-Western part of the study area and accounts for about 27% of the total area of Eastern U.P. The Southern upland (i.e. Mirzapur) is less affected by floods due to its topographic condition. The two districts Pratapgarh and Sultanpur are affected by rivers which originate in plain and low rainfall area, besides this, these districts have much Bhangar land. The North-Western part of this zone is somewhat higher and so experiences low flood intensity. In this zone only Mirzapur district receives flash flood due to its rocky surface. Even in the year of severe flood (1978), Sultanpur remained unaffected.

8. Nature of the flood problems in Eastern Uttar Pradesh :

The drainage system in Eastern U.P. in general and in the basin of the Rapti and its affluents in particular is known to be imperfect, in the sense that the valleys of Rapti, Rohin and the Ami are broad, especially in their lower reaches and sufficiently depressed to confine the flood waters within themselves without draining them off as they occur. The district Gazetter of Gorakhpur reports that extensive inundation occurs in these valleys and in years of heavy rainfall, the entire area is submerged. This occurs constantly in a very large tract to the South and West of Gorakhpur where the swollen volume of the Rapti holds up the water of Rohin and Ami at the respective points of junction, resulting in the formation of two huge sheets of water in the Domingarh Lake and the Amiar Tal. Similar floods occur from time to time in the South-West corner of the Bansgaon Tehsil along the course of the Kuwano.

The mechanics of the flood flows in the Rapti leading to the formation of raised banks by the deposition of silt, with consequent changes in channels of flow is described by the Gazetteer in the following words :

"Both the Rapti and the Rohin carry enormous quantities of silt and when the stream overtops its banks most of the silt is deposited within a short distance of the river bed, so that, in course of time, raised levees or banks are formed adjoining to the river bed channel, while the lowest portion lies close to the old high banks on the outermost extremities. These raised embankments are seldom continuous, for breaks at the junction of tributary streams and also where erosion sets in at the angles of bends in the river's course. The valleys so formed would be submerged only in abnormally wet seasons. In order to prevent inundation of the low lands, artificial embankments are nessary at neighbouring villages, but for want of engineering skill and a general unwillingness to use sufficient money on such works these do not get constructed".

TABLE 3

Natural Depression Possible to be Converted into Temporary Detention Basins

S. No.	Name of Tal	Location of Basin Latitude	Location of Basin Logitude	Area (sq. km)
1.	Sitadohar Tal	27°32.5′ — 27°33′	81°54′ — 81°55′	2.14
2.	Keraogarh Tal	27°24′ — 27°25.5′	82°57′ — 82°20.5′	3.65
3.	Mubarakpur	27°16′ — 27°18.5′	82°31.5′ — 82°37′	13.34
4.	Nakchhedwa Tal	27°21′ — 27°24′	82°45′ — 82°50′	14.74
5.	Bajra Bahri	27°20′ — 27°22′	82°50′ — 82°51′	8.43
6.	Khelwal Misr	27°15′ — 27°19.5′	82°54′ — 82°59′	13.89
7.	Chaur Tal	27°12′ — 27°14.5′	82°54′ — 82°58′	10.30
8.	Semrahia Khalsa	27°22.5′ — 27°27′	82°57′ — 83°0′	9.77
9.	Saura Tal	27°3′	83°13′	8.24
10.	Bakhira Tal	26°52.5′ — 26°57′	83°5.5′ — 83°12.5′	23.85
11.	Likhia Tal	26°50.5′ — 26°51′	83°0′ — 83°19.5′	14.77
12.	Jahda & Chilua Tal	26°48′ — 26°57′	83°19.8 — 83°27′	21.88
13.	Ramgarh Tal	26°44′	83°26′	4.84
14.	Nadar Tal	26°38′	83°25′	3.38

Taking 0.1m depth of water, total capacity of the detention basins is 0.03m ha m.
Source: Report of Central Water Commission (1957).

The drainage impact in the Rapti valley is extensive inundation in the rainy season, covering large tracts of the valley and its vicinity. In the years of heavy rainfall, the entire area is submerged. The Rapti carries an immense quantity of silt, particularly in the rainy season. This has gradually raised its bed so that at several places, it stands above the level of the surrounding country. Heavy floods take place whenever the river overflows its low banks or holds back the water of its tributary streams. Its natural levees, although not very high, also holds back the surface run-off of the area. The area South and West of Gorakhpur city experiences extensive inundation as the Rapti holds back the waters of Rohin and Ami rivers at their respective points of junction.

9. Past Effort of flood control:

Before independence, the Palmer in 1898, the Watal in 1938 and the flood conference in 1939 had investigated the flood problems of Rapti basin and suggested suitable measures. After independence, Government of U.P. in 1948, appointed a committee to survey the affected areas and suggest measures to minimise the adverse effects. The committee reported that the flood problems were due to reduction in absorptive capacity of the soil by indiscriminate cutting of forests. The remedial measures suggested were re-afforestation of hill slopes and anti-erosion measures. The diversion of flood flows from one river to another was not found feasible in U.P.

The Central Water Commission in 1957 proposed 200 feet high dam site near Jalkunda in Nepal with storage capacity of 3.5 m.a. ft. Thirty seven number small storage reservoirs were also proposed at various tributaries of river Rapti with total capacity about 15790 m.c. feet (0.36 m. a. feet). The fourteen natural depressions have been recommended as given in Table 3.

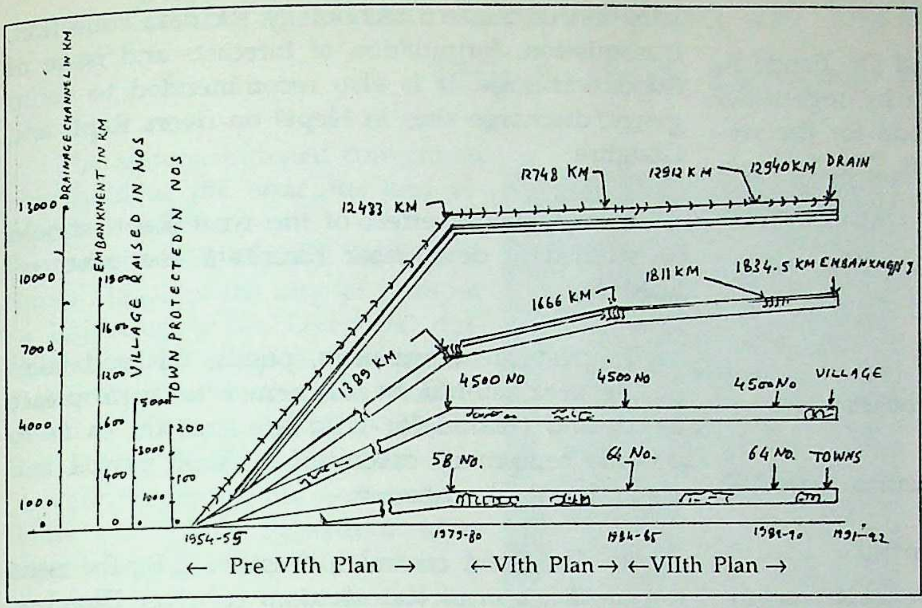
In 1983, the Investigation and Planning (flood) Division, U.P. Irrigation Department suggested the

TABLE 4

Features of Floodways through Drains/Shortest Distance

Features	Name of Floodways Tehari	Manwar	Kuwano	Ami
Bed width (m)	115.50	115.50	115.50	115.50
Depth (m)	4.57	4.57	4.57	4.57
Side Slopes	1:1	1:1	1:1	1:1
Length through				
I. Drain (km)	115.00	110.00	105.00	60.00
II. Shortest Distance (km)	65.00	65.00	70.00	70.00

Source: Report of Irrigation Department, U.P. (1983).



Physical achievement in flood control during 1954-55 to 1991-92 in U.P.

following alternative proposals for flood control in Rapti basin :

(a) Creation of a detention reservoir with 82000 m.c. feet (2322.95 m.c.m.) capacity, 33 m high 80 km long dam at the foot of Dundawa hills with five barrelled 15 km tunnel with a diversion dam in Nepal.

(b) Four nos. flood diversion ways along shortest distance each of 708.22 cumecs with regulators and silt ejectors of river Rapti providing 77% solution to the problem as given in Table 4.

(c) Eight meter high, 80 km long dam at the foot of Dundawa hills plus four floodways along natural drains of rivers as far as possible :

  (i) Construction of 24 nos. small reservoirs including remodelling of existing 12 nos. bunds for flood absorption.

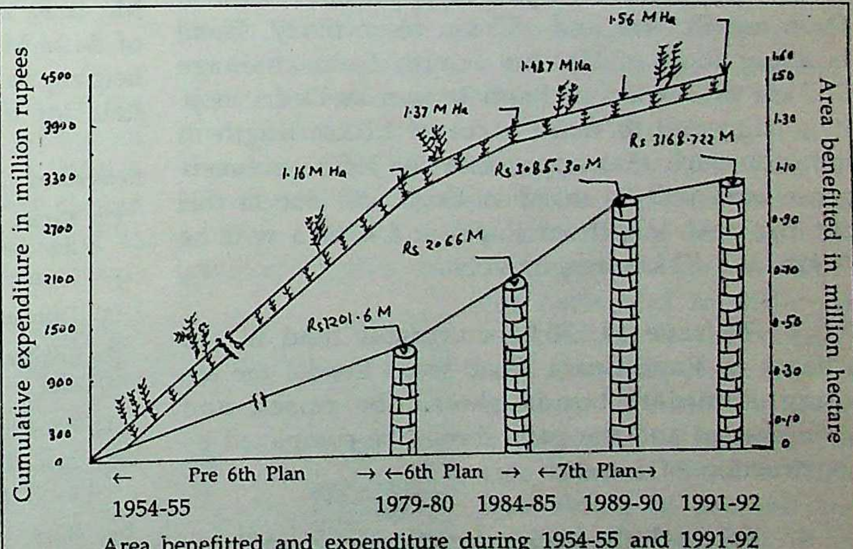
  (ii) Construction of 879 km marginal bunds on both banks of river Rapti and its tributaries.

  (iii) Construction of 1250 kms drains in the Rapti basin.

10. Indo-Nepal water resources agreement 1992 :

India needs the co-operation of Nepal for protecting ecology and for saving the Gangetic plains from the floods caused by rivers originating in Nepal. India and Nepal were working together upto year 1960 to harness river waters that flow from Nepal to India for generation of power and irrigation potential besides protecting the people from floods that cause devastation year after year. But after 1960, the collaborated works between the two countries were stopped due to various reasons. Qualitative improvement between the two countries again started since June 1990 by the visit of Nepalese Prime Minister to India, carried forward by Indian Prime Minister visiting Nepal in February 1991 and then the visit of Nepalese Premier to India in Dec. 1991 for bilateral co-operation in water resources sector. High level delegations of India led by Prime Minister visited Nepal on October 19 to 21, 1992 and an agreement was signed between the two countries in the area of water resources development and flood control.

The Indo-Nepal Water Talks 1992 decided on a time frame for investigations and preparation of detailed project reports for execution of Karnali, Pancheshwar and Sapt-Kosi multipurpose Projects and medium size projects like Burhi Gandak flood forecasting and warning system including flood protection embankments along the rivers Kamala, Bagmati, Lal Bakaiya and Khandu by June 1993 (Hindustan Times, October 24, 1992). Both the Governments agreed to set up an office in Nepal in December 1992 for completion of feasibility reports. The details of some of the important projects are given below.



Area benefitted and expenditure during 1954-55 and 1991-92

Flood protection in U.P.

11. Yadav & Lal formula :

In 1994, Er. Ramanand Yadav and Dr. Pande B. B. Lal developed a regional formula by regression method for estimation of future floods for the rivers (except Ghaghra) of Eastern U.P. The formula is :

$$Q_T = 1.83(1+0.6 \log T)\ A^{0.74}$$

For Ghaghra River

$$Q_T = 1.88(1+0.6 \log T)\ A^{0.78}$$

where A = catchment area of the basin

T = return periods

Q_T = expected discharge at return period T.

12. Recommendations for flood control :

The following suggestions have been recommended for flood control in Tarai region of Eastern U.P.

1. A regulator has been recommended at the head of Gurra river to regulate the present trend of increasing discharge in Gurra river year by year and control the spilling of water during floods. The regulator will also act as a bridge to provide access in this remote area to improve the backwardness of the Doab.

2. The present lengths of Rapti and Gurra in Doab are 53.1 km and 48.5 km respectively. There is a big loop of 10.1 km length from chainage 31.7 km to 21.6 km of Rapti known as Dadri loop. It is suggested to make a cut of 1.0 km length in the loop such that approximately 350 ha submergence land will be saved in Doab and due to this cut the new length of Rapti and Gurra will be 44 km and 52 km respectively.

3. To save 14,170 ha culturable land of 145 villages in Rapti-Gurra Doab from floods, the existing Zamidari bunds should be raised and strengthened and the gaps should be completed by construction of bunds.

4. To check the backwater effect of river Rapti, a regulator on river Ami at a distance of 1 km from confluence point has been suggested near Kauriram town along with an earthen embankment between Sohgaura bund and Malaon bund.

5. Guage and discharge sites should be established at suitable places like Maghar, Chhatai and Kauriam on river Ami and bifurcation point on river Gurra permanently for flood forecasting with adoption of modern technology for data collection, transmission, formulation of forecasts and issue of flood warnings. It is also recommended to setup gauge/discharge sites in Nepal on rivers Rapti and Ghaghra.

6. Backwater effect of the river Rapti should be studied in detail near Kauriram and other related areas.

7. Natural depressions, ponds, tals and lakes in the area should be deepened to appropriate depth and cleared for wild life growth, so as to provide temporary detention in flood period and water for Rabi irrigation.

8. For flood control in Eastern U.P., the need for construction of Karnali dam on river Ghaghra, Bhalu and Jalkundi dams on river Rapti, Pancheswar and Purnagiri dams on river Shadra in collaboration of Nepal Government has been emphasised.

Acknowledgement :

The authors are greatly indebted to Ministry of Human Resources Development, Government of India for providing financial assistance to project entitled 'Management of Flood problems in Eastern Uttar Pradesh' and also to Mr. Vishnu Swaroop & Mr. B. K. Bajpai, Computer Engineering Department of M.M.M. Engineering, College, Gorakhpur for helping to complete the project and analysing the data for the same.

References :

(1) Bajpai, M. P. & Mishra, M. L. (1939), 'The 1938 floods in the eastern united provinces' Cal. Geog. Dev. Vol. II, No. 2, June.

(2) District Gazetteers of Gorakhpur, Basti and Gonda districts.

(3) Lal, Pande B. B. (1987), 'Floods in Eastern Uttar Pradesh and its Control', Prakrti Vol. I, pp 5-10.

(4) Reports of U.P. Irrigation Department.

(5) Report of Central Water Commission (1957), 'Flood Studies of River Rapti Vol. I', CWC, New Delhi.

(6) Singh, Bharat (1988), 'Flood Control problem in India with special reference to Ghaghra Basin', Keynote Address, M.M.M. Engineering College, Gorakhpur.

(7) Yadav, R. (1994), 'Flood Problems and Characteristics of river systems in Tarai Region of Eastern U.P.', Ph.D. Thesis, unpublished, M.M.M. Engineering College, Gorukhpur, University of Gorakhpur.

(8) Yadav, R. and Pande B. B. Lal (1995), 'Flood problems in Eastern U.P. with special reference to Rapti Basin' IWWA, April-June pp 89-94.

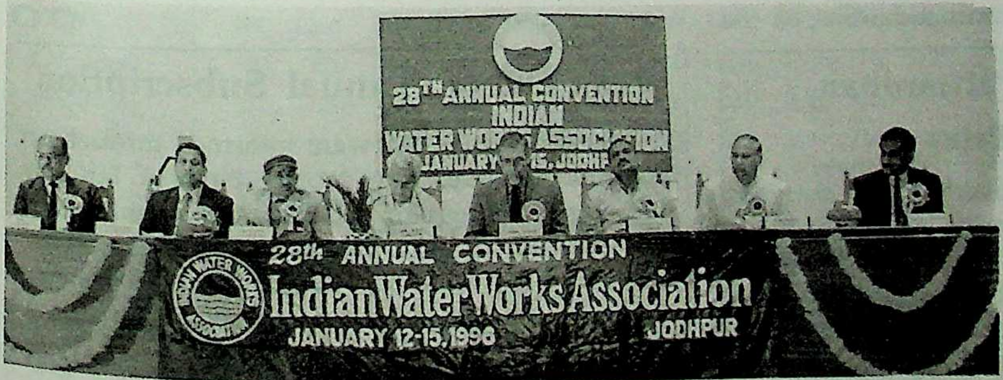
28th Annual Convention of IWWA — Jodhpur

12th to 14th January 1996

←
Special invitee Er. M. J. Slipper (Hon. Sec. Gen. IWSA) lighting the lamp to mark the inauguration of 28th Annual Convention of IWWA at Jodhpur on 12-1-1996.

The abovementioned convention was held at the spacious and elegant auditorium of Dr. Sampoornanand Medical College in Surya Nagaree, the city of Jodhpur in Rajasthan state. Over 180 delegates and 60 spouses attended the same. The convention was inaugurated at 11.00 a.m. on 12-1-1996 by the Chief Guest, Hon'ble Shri Jaswant Singh Vishnoi — State Minister of P.H.E.D. Rajasthan. Messages of good wishes and success to the convention, received from Hon'ble Bherosingh Shekhawat, Chief Minister of Rajasthan, Shri Balram Jakhar (Minister for Agriculture, Govt. of India) & Shri Rajesh Pilot (Minister for Environment & Forest, Govt. of India), were read out by the Hon. Secretary. Dr. Khet Lakhani, the Mayor of Jodhpur city, welcomed the gathering on behalf of the citizens of Jodhpur, while, Er. Shri M. R. Parihar, the chairman of the Organising Committee of the Convention (and also that of Jodhpur local centre of IWWA) welcomed the audience on behalf of the organising committee of the convention.

Multi-coloured turbans were then offered to the dignitaries on the dais as per the local tradition of welcoming the VIPs. Retiring President of IWWA, Shri S. S. Raghuvanshi introduced the newly elected President, Shri R. M. Sagane (presently working as the Member Secretary of Maharashtra Water Supply and Sewerage Board) who then gave his highly informative and thought-provoking address on 'Water supply and Sewerage — Sectoral Needs'. Then spoke the Secretary General of International Water Supply Association (IWSA), Mr. Michael Slipper, who was a special invitee to the convention. He appreciated the good work of IWWA and assured help and support from the International body — IWSA. Prizes were then given to authors of the best papers published in the journal of IWWA and for good lectures delivered at different local centres during the year 1995. Shah Memorial Shield was awarded to Calcutta Centre — the best managed local centre during the year 1995. The volume containing souvenir and technical papers of the convention and IWWA's publication in Hindi (authored by Dr. D. D. Ozha, an active member of Jodhpur centre and professor Dr. T. A. Sihorwala, (Chairman of Indore Centre) on 'क्लोरीनीकरण एवं क्लोरीनीकारक यंत्र' was then released at the hands of the Chief Guest. Thereafter the Chief Guest of the function, Hon'ble Minister for PHED, delivered his address and congratulated IWWA for the work being done by it in bringing together water engineers working in different parts and in different organisations of the country, to a common platform for exchange of views and ideas and holding discussions. He also thanked the I.W.W.A. for holding its present Annual Convention in Rajasthan at Jodhpur and arranging technical sessions on the important theme of 'Water supply management in arid and semi-arid regions', which was most relevant to the conditions in Rajasthan state.



At the inaugural function of the 28th Annual Convention of IWWA at Jodhpur on 12-1-1996. From left : Er. R. Natarajan, Hon. Sec. Gen. IWWA; Er. K. M. L. Mathur, Organising Secretary of the Convention; Er. M. R. Parihar, Chairman of the Organising Committee; Dr. Khet Lakhani, Mayor of Jodhpur Municipal Corporation; Er. M. J. Slipper, Hon. Sec. General, IWSA; Shri Rajendra Gehlot, M.L.A. from Jodhpur, Rajasthan State Assembly; Er. S. S. Raghuvanshi, retriring President I.W.W.A. and Er. R. M. Sagane, President Elect (1996-97) IWWA.

Following the inaugural function, Shri N. V. Modak Memorial lecture and Shri Raman Endowment lecture were delivered. The first lecture was on 'Water, sanitation and health, with special reference to the water related health problems of Rajasthan', by Prof. K. J. Nath (former Chairman, IWWA's Calcutta local centre) who is presently working as the Director of All India Institute of Hygiene and Public Health, Calcutta; while the other was on 'Water Resources and their management in the Indian arid zone', by Dr. A. S. Faroda, Director, Central Arid Zone Research Institute Jodhpur. The full text of these highly informative lectures is published in this issue for the benefit of those who could not attend the convention and for other readers of this journal.

The convention had 7 technical sessions in which over 23 papers were presented on different sub-themes and had 1 commercial session in which 5 commercial firms gave beautiful presentations of their products & activities, with the help of slides, transparencies and video tapes. These sessions were chaired by eminent water/environmental engineers who were specially invited by the organisers. These sessions were followed by discussions wherein delegates raised several questions which were replied to their satisfaction.

The technical sessions were followed by an Open House session in which the delegates were given an opportunity to express their thoughts and views on the conduct of this convention and working of the Association so as to get a feedback.

This was followed by the valedictory function, which was chaired by Er. Prem Swaroop Rajvanshi (former Advisor C.P.H.E.E.O.), wherein prizes were given to three best papers presented at this convention (see page 120). The recommendations of the seminar in a draft form were then placed before the delegates for discussion and adoption. Finally the Chairman of Calcutta local centre invited the Association to hold its next (29th) Annual Convention at Calcutta in early January 1997.

The Organising Committee of the convention had arranged for interesting cultural programme consisting of thrilling and enchanting solo and group folk dances of Rajasthan in which Bhawani dance of Ms. Jyothi Bhati was most thrilling. Highly intelligent and humorous mimicry programme and jokes were presented by Mr. Khan, a local artist. All delegates and other audience, enjoyed it very well.

The banquet of the convention was held on the spacious, open, soft green lawns of the magnificent Umedsinh Palace in Jodhpur city and was hosted by Reliance group of industries. The delegates enjoyed the delicious dishes to the tunes of Rajasthani music and dance.

A technical exhibition was arranged at the venue of the Convention in which several companies participated and displayed their products and services. A special programme of local tours and shopping was also arranged for accompanying spouses of the delegates and they enjoyed the same. The convention was followed by technical and site seeing tours to nearby places of interest and the delegates enjoyed the rich and colourful culture of the Rajasthan state.

The convention was a great success and the credit for it obviously goes to the untiring hard work put in by its organising committee led by the Chairman of the Jodhpur centre, Er. M. R. Parihar and the young dynamic Hon. Secretary, Er. K. M. L. Mathur.

❐ ❐

Late Shri S. V. Patwardhan Memorial Prize

A prize of Rs.251/- is available to the authors of the best paper written during a year on any topic on 'Water Treatment'. Members who have carried out innovative work on any aspect of Water Treatment and related matters to solve the actual field problems for achieving economy or simplicity of operation and improving its effectiveness may please prepare and send their papers to the editor of our journal for publication. The general guidelines are published in earlier issues of this Journal.

Payment of Annual Subscription

Members of IWWA were informed through an announcement on the second page of January 1996 issue of this journal, that **the membership subscription for the year 1-4-1996 to 31-3-1997 was payable before 31st March 1996.** ***Please pay the same immediately if not paid so far.***

This issue of the journal is posted as a gesture of goodwill to all those who have yet not paid their subscription dues. Copies of further issues of the journal of IWWA will be sent to them only on receipt of their membership subscription.

SHORT COMMUNICATIONS

1 Environmental Sanitation Quality in Public Utility Services in a Pilgrim Town — A Case Study of Tirupati

N. Kumara Swamy* & B. Suresh Ram**

Tirupati is a well-known pilgrim town in South India, situated on the longitude of 79°27′ E, latitude of 13°40′ N and at a height of 500 feet above mean sea level. The town has a population of about 2.5 lakh and more than 10 lakh pilgrims visit this temple town annually. Maintenance of good environmental sanitation in all public places has become a very difficult task due to the high and increasing floating population.

Environmental sanitation quality survey was therefore conducted in various public utility service places in this town to assess the status. A questionnaire was prepared and distributed to institutional heads or concerned authorities of 17 public utility services such as colleges, schools, bus stations, theatres, railway stations, hostels, hospitals etc. to collect information regarding quality of water consumption, storage facilities, pollution control measures, number of sanitary appliances, frequency of cleaning and mode of disposal of waste water. Thirtyfour water samples were collected from different public places in the town during October 1994 and March 1995, and were analysed for usual Physico-Chemical parameters using Standard Methods, (Table 1). Quantity of water supplied per capita per day in public places was determined. (Table 2). Status of sanitary appliances and their maintenance was collected through a detailed survey. (Table 3). Water quality and number of sanitary fittings available in all public places has been compared with standards stipulated by BIS. (Bureau of Indian Standards).

It was observed that:

1. Total dissolved solids and hardness exceeded the permissible limits in 90% and 72% of water samples.
2. Quantity of water supplied was inadequate.

TABLE 1

Physical & Chemical Qualities of Drinking Water Samples

Parameters	Sample Nos.																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Temperature	24	24	24	24	26	21	24	26	26	24	24	24	24	24	23	26	25
p^H	7.68	7.55	7.17	7.39	7.36	8.12	7.58	7.74	8.25	7.41	8.11	7.71	8.15	7.68	7.7	7.74	7.63
Conductivity	0.41	0.8	1.2	1.24	0.24	1.24	2.7	1.72	0.25	1.10	0.32	1.87	0.36	1.97	1.99	1.85	2.4
Acidity	16	100	44	88	48	20	24	60	40	40	44	20	64	24	64	92	88
Alkalinity	20	52	44	48	48	20	68	140	84	56	4	32	108	28	84	104	104
T.D.S.	800	1200	600	1200	1324	1000	1400	1584	1000	80	820	300	780	740	700	740	1788
Chlorides	24	152	102	144	180	34	138	432	160	30	152	26	212	46	310	246	104
Fluorides	0.2	0.1	0.4	0.6	0.2	0.3	0.4	0.2	0.5	0.2	0.6	0.4	0.3	0.2	0.1	0.8	1.0
Hardness	180	424	340	480	488	196	392	804	620	240	492	228	700	232	696	740	754

- - - - > Sample
- - - - > All parameters are expressed in mg/l except p^H
T.D.S. - - - - > Total Dissolved Solids.

1. S. V. Engg. College
2. S. V. Oriental School
3. S. V. U. High School
4. S. G. S. High School
5. S. V. High School
6. S. V. Arts & Junior College
7. Pratap Theatre
8. C. B. Station
9. Municipal Office
10. S. V. Junior College Hostel
11. Administrative Building
12. Mahavir Theatre
13. Palani Theatre
14. S.V.I.M.S.
15. Railway Station
16. S.G.S. College
17. D. R. Mahal Theatre

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* Asst. Professor, Environmental Engg., Laboratory, K.S.R.M. College of Engineering, Cuddapah-516003.

** B. Tech. Student, K.S.R.M. College of Engineering, Cuddapah.

TABLE 2

Quantity of water supplied in public places

Sample	Source of Water	Size of Storage Tank in litres	Quantity of Water supplied per capita (lpcd)
1.	Borewell	70000	140.91
2.	Borewell	1000	4.44
3.	Borewell	18375	15.70
4.	Borewell	***	***
5.	Borewell	24000	44.21
6.	Kalyani Dam & DW	90000	43.74
7.	Borewell	6000	7.81
8.	Openwell	30000	—
9.	Borewell	25000	53.25
10.	Kalyani Dam & Well Water	121000	113.97
11.	Kalyani Dam & BW	80000	10.67
12.	Borewell	5000	7.69
13.	Borewell	3000	5.00
14.	Kalyani Dam	54000	223.86
15.	Borewell	180000	72.87
16.	Borewell	6000	11.11
17.	Borewell	3000	4.35

Note :

— Data not collected

*** Under construction

TABLE 3

Status of sanitary appliances in public places

Sample stations	No. of Taps	Wash basins	Bathrooms	Urinals	Water closets	Cleaning agents	Frequency of cleaning in a day
1.	60*	26*	6†	30*	12†	Bleaching Powder	Once
2.	3†	2†	5†	2†	2†	Nil	Once
3.	20†	3†	11†	20†	10†	Bleaching Powder	Irregular
4.	7†	2†	Nil	8†	4†	Bleaching Powder	Once
5.	8†	Nil	10†	60*	10†	Nil	Irregular
6.	19†	14†	8†	12†	12†	Bleaching Powder	Once/Week
7.	2†	1†	1†	25*	4†	Phenol	Once
8.	42*	Nil	10*	51*	30*	Phenol	Once
9.	33*	24*	4†	122*	30*	Bleaching Powder	Once
10.	72*	12†	44*	8†	40*	Bleaching Powder	Once/Week
11.	100*	24†	10†	36†	24†	Bleaching Powder	Once
12.	2†	Nil	1†	25*	7*	Bleaching Powder	Once
13.	2†	1†	1†	30*	6*	Bleaching Powder	Once
14.	300*	50*	40†	60*	20*	Bleaching Powder	Thrice
15.	58†	29†	40*	24†	40*	Bleaching Powder	Once
16.	40*	20†	5†	60*	15†	Phenol	Once
17.	2†	1†	1†	24*	7*	Phenol	Once

* Upto Standard in providing the sanitary fittings

† Not upto standard in providing the sanitary fittings.

3. Schools and theatres had not provided adequate number of sanitary fittings as stipulated by the BIS.
4. Water supply and sanitation were given the least priority in all public utility service places.
5. Environmental awareness among the users and public authorities was lacking.

2

Selection of pipe size for outlet in service reservoirs and sump

P. Mariappan*

Water supply schemes will generally have service reservoirs which help in maintaining the minimum residual pressure as required in the distribution system. Treated water is first taken to these reservoirs either by pumping or by gravity and is then discharged into the distribution system at a defined rate for certain design period. The size of the outlet of a reservoir through which water flows into the distribution system has to be such as to give the desired discharge for the design period. Factors which decide the size of the outlet are, the depth of water storage, diameter of the circular reservoir and the period (number of hours) of distribution of water. Storage depth is a difference between maximum water level (MWL) and low water level (LWL) where the outlet is fixed. Water stored up to MWL is allowed to go down upto LWL in the design distribution period (once the hydraulic analysis of this system is carried out assuming the outlet to be a mouth piece with varying head).

The analysis for both pumping and gravity systems is based on basic hydraulic equation

$$Q = Cd\ A\sqrt{2gH}$$

For pumping system (figure no. 1)

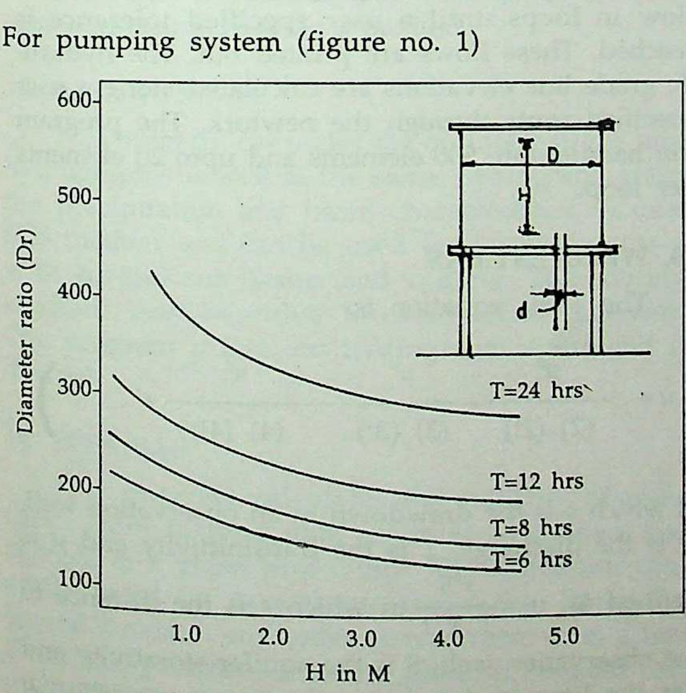

Fig. 1

$$Dr = 405/H^{0.25} \text{ for } T = 25 \text{ hrs — (urban system)}$$

$$Dr = 202/H^{0.25} \text{ for } T = 6 \text{ hrs. — (Rural system)}$$

For gravity system (figure no. 2)

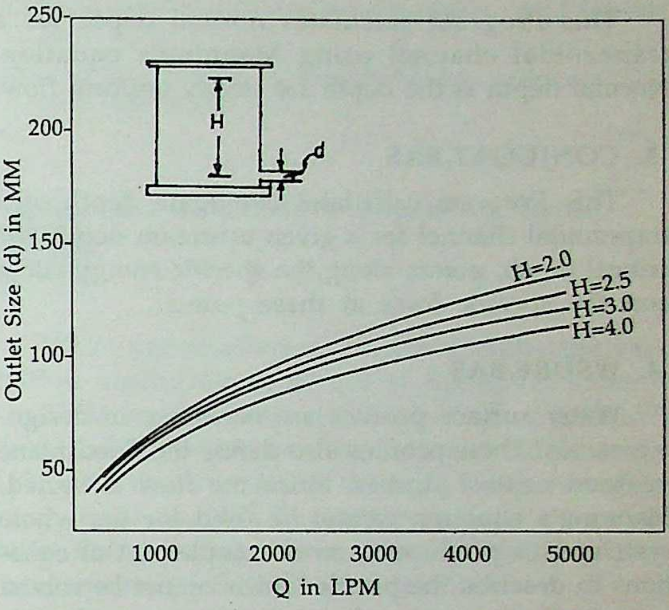

Fig. 2

$$d = a/(2.973\ H^{0.5})$$

Where d = mouth piece diameter

Dr = ratio between the diameter (D) of the tank and the diameter (d) of the mouth piece

H = Storage depth (MWL — LWL) in metres

Q = discharge in Lpm.

3

Microcomputer Applications — I

R. A. Altekar*

Introduction :

14 programs in BASIC are available in the book 'Microcomputer Applications in Water Resource', by Otto J. Helweg, published by Prentice Hall Inc. in 1991. Information about these Programs is given below :

1. MANNING.BAS

This Program calculates the discharge in the

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* Puliamarathukottai (P.O.), Vedasandur-624 710, Dindigul Anna Dist. (T.N.).

* Shah Technical Consultants (P) Ltd. Mumbai-400021.

trapezoidal channel using Manning's equation. Rectangular and triangular channels are special cases of trapezoidal channel.

2. NORMAL.BAS

This Program calculates normal depth for a trapezoidal channel using Manning's equation. Normal depth is the depth for steady uniform flow.

3. CONJUGAT.BAS

This Program calculates conjugate depth of a trapezoidal channel for a given upstream depth, the critical depth, points along the specific energy curve and the specific force at these points.

4. WSURF.BAS

Water surface profiles are necessary in designing canals. These profiles also define the flood plane in flood control studies. Since the flow is varied, Manning's equation cannot be used for the whole system. This produces a more complex set of equations to describe the profile which cannot be solved analytically; consequently an interactive method is necessary. In the case of prismatic channels the direct step method is often used.

This program can analyse channel sections that are rectangular, trapezoidal, circular or modified horseshoe. The program defines water surface profile as one starting upstream and proceeding downstream as is the case for the supercritical flow. Subcritical flow profiles are called backwater curves.

5. SIDE WEIR.BAS

Side weirs are a common means of flow diversion and are frequently used for water level control. This program calculates critical and normal depths for a given situation. From a comparison between weir height and critical depth upstream of the weir, the modes of flow along the weir are classified and the water surface profile along the weir calculated. At each section, discharge in the channel, distance along the channel, water surface slope and pressure plus momentum are calculated and printed out. The total discharge over the weir is calculated. The program allows for side weirs on both sides of the channel.

6. WEIR.BAS

This program calculates discharge over a sharp crested rectangular weir given the weir length, height of water above the weir crest and the distance between the channel bottom and weir crest.

7. FLUME.BAS

This program calculates discharge by a Parshall flume given the throat width of upstream elevation.

8. PIPESYS.BAS

This program solves the energy equation for head loss between two stations. You need to enter elevations at the two stations and pressure at one if you want the program to solve for the other pressure. You also need to enter characteristics of the pipes and fittings between the 2 stations. The pipe section of the program assumes values for viscosity if desired and displays a table of absolute roughness values in case the user needs to estimate from the table. The program first calculates the Reynolds number and then calculates the relative roughness factor. With these, it calculates the frictional factor. Finally the program calculates the head loss in the pipe.

9. PIPENET.BAS

This program uses the Hardy-Cross method directly and can solve network problems using English units or Metric units. It calculates head loss in pipes either by the Hazen-William's formula or the Darcy-Weisbach formula. Pipes, pumps, pseudo loops are called elements. Where the elements join are called junction. The program first balances the flow in loops until a user specified tolerance is reached. These flows are printed out. The hydraulic grade line elevations are calculated along a user specified route through the newtork. The program can handle upto 500 elements and upto 20 elements per loop.

10. WELLTEST.BAS

The Theis equation is

$$s = \frac{Q}{4 \Pi T}\left(-0.5772 - \ln u + u - \frac{u^2}{(2)\ (2!)} + \frac{u^3}{(3)\ (3!)} - \frac{u^4}{(4)\ (4!)} + \ldots\right)$$

in which s is the drawdown in an observation well, Q is the discharge, T is the transmittivity and u is defined as, $u = \frac{r^2 S}{T \ x \ t}$ in which r is the distance to the observation well, S is the aquifer storativity and t is the time in days since the pump was started.

The program solves Theis equation.

11. FASTEP.BAS

The step drawdown test yields aquifer characteristic (transmittivity) and also solves the well function or step draw down equation, which includes well losses.

$$s = BQ + CQ^{P}$$

in which s is drawdown, Q is discharge and B, C and P are the parameters to be solved by the test.

Given equation above and points from the step-draw down test, the computer uses a least squares test to find the parameters B, C and P.

12. QOPTIM.BAS

The program calculates the discharge required to maximise net benefits; no discounting is assumed because benefits and cost occur at the same time throughout the life of the well. QOPTM.BAS maximizes the objective function

$$\max\ (K_1\ T_1\ Q) - K_2\ T_2 \quad \frac{Q(T\ D\ H)\ (0.746)}{3960\ e\ o}$$

where K_1 is the cost of alternative water. T_1 the time the well is pumped, Q is the discharge, T_2 time pumped in hrs. TDH is the total dynamic head and e o is overall efficiency.

Since the equation is concave, the maximum is found by differentiating it and setting the result to O. This yields a transcendental function so Q is determined using Newton's method.

13. RAINRUN.BAS

This program calculates the ordinates to the unit hydrography as well as the storm hydrograph given the precipitation and basin characteristics. It uses SCS method and can be used for a complex basin with several sub-basins and routing. The routing methods may be either Muskingum or reservoir. The program prints out hydrograph at the end if desired.

14. FFFA.BAS

This program calculates the statistics of river flows from historic data in order to predict discharges of a given probability. The floods are generally rated by exceedence frequency. Enter the annual floods in any order or read them from a file. Enter the parameters to the plotting position formula. The program then gives option of using computed skew, calculating the weighted skew or entering your own choice for the skew. You are then given the option of entering K values by hand or having the program calculate. The program then asks for the exceedence floods desired for output.

Reference :

Microcomputer Applications in Water Resources, Otto J. Helweg, 1991.

ISBN 0 — 13 — 582479 — 6, Prentice Hall Inc., Englewood cliffs, New Jersey 07632.

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4

Rural Sanitary Marts in India

While universal access to sanitation by the year 2000 is among the goals set at the world summit for Children, the National Sample Survey (1988-89) indicates that latrine coverage in rural India is only 11%. Of this, only 3% is through the government programme and 8% through household's own efforts. There is thus a tremendous potential to promote sanitation through private initiatives.

As of 1990, around 100 million rural households and 14 million urban households in India did not have access to a latrine. It is impossible to get the necessary Rs. 20,000 crores or more from government sources, but promoting sanitary facilities through private initiative seems to be a plausible solution to reach the goal of universal access.

The subsidy-linked government sanitation programme, which is confined to selected areas of a state, leaves much of the population unserved. Many households would like to have their own sanitary facilities without waiting for government subsidy. These people need the know-how and ready availability of construction materials at a reasonable price and within close proximity. Establishment of rural sanitary marts (RSMs) is an alternative for the existing subsidy-linked system in India. It is a step towards commercialising the provision of appropriate sanitary facilities in rural and peri-urban areas, and facilitates the private initiative for accelerating sanitation coverage.

Rural sanitary marts are outlets dealing in all the materials and services needed for construction of latrines, soakage pits and other facilities including guidance on construction. They can become important points for dissemination of knowledge on environmental health and sanitation, ultimately bringing about behavioural change. It is thus a commercial enterprise with a social objective.

Selecting the product mix. : The number of latrines constructed is a generic indicator of the marts effectiveness in accelerating sanitation coverage. As this is the primary objective of the marts, it must be kept in mind when determining the product mix to be stocked. The RSMs should carry several categories of materials :

- ☐ materials for construction of various types of latrines and other sanitary facilities (such as pans, pit covers, pipes, doors)
- ☐ items relating to home sanitation (such as food safes, ladles, water filters, materials for cleaning latrines)
- ☐ items relating to personal hygiene (popular soaps, nail cutters, footwear).
- ☐ in areas where community based hand pump maintenance is introduced, essential hand pump parts and a list of local mechanics' addresses.

Location : The location of the RSM should be such that the venture is economically workable and eventually self-supporting, such as market towns with rich surroundings, expressed in terms of high irrigation and cropping intensity. A marketable surplus of agricultural produce usually indicates that people can afford to buy sanitation facilities. Such areas generally have a greater need for latrines due to a lack of open land available for defecation. High population density and high literacy levels will also contribute to the success of an RSM.

Who should run it ?

Selection of the right type of agency to run the RSM is a large factor in its success. The agency should have adequate experience in manufacturing and/or trading for the rural market. Cooperative marketing outlets and well-established and interested NGOs are examples.

Financing :

There are two financial requirements for running an RSM :

- ☐ funds to meet one-time non-recurring costs (furnishings, sign boards);
- ☐ funds to meet working capital requirements of a recurring nature (inventory, sales promotion, rent, electricity, salaries).

The working capital must be correctly estimated and managed and there should be a short turnaround time in the stock, so as to maximize the return on the invested capital. Funds should be raised from the agency's own resources, or through a bank loan. Assistance from a donor organisation or the national government could also be sought.

A production centre :

To obtain its supply of materials, the RSM can manufacture some of its own items, or link with production centres in the area. Where a few RSMs are already operating, a network where each RSM produces selected items to sell to the others, would help. This, of course, will require additional financial support for meeting fixed and working capital requirements.

(Source : Adopted from the article 'Rural Sanitary Marts' by B. B. Samanta, Sanitation Coordinator, UNICEF, New Delhi, India)

(Ref. : Water Newsletter — page 1 & 2 No. 238, November, 1995).

5

Operation and Maintenance Today : Constraints and Trends

Operation and Maintenance is crucial to the successful management and sustainability of water supply and sanitation systems, whatever the level of technology, infrastructure and existing institutional framework. The benefits of effective O & M are clear : improved health and well-being and social, economic and financial advantages. Nevertheless, in the past the O & M of water supply systems of small communities has been neglected in a great number of developing countries. According to the World Health Organization it is estimated that 30 to 60 percent of existing water supply systems are not operational, having an important impact on the well-being of the populations concerned.

Operation and maintenance is not limited to the sole activity of a caretaker or a technician; it includes the activities of various actors at different levels. It requires forward planning and technology transfer at all stages of the project cycle, from installation of plant and equipment, through operator training and handover, to routine operation and upkeep, including purchasing of spare parts, repair procedures and financial management, as well as best practice in operating and maintaining the system.

Constraints :

Proper O & M has been subject to many constraints in the past. Among the many factors that have been found to contribute to inadequate O & M procedures are :

- the low profile of O & M, and the lack of priority it is given by policy makers;
- lack of clear policies, appropriate legal frameworks and a well-defined division of responsibilities to support O & M.
- too much political interference, i.e. provision of free water, which makes sustainability difficult to achieve;
- Governments and external support agencies (ESAs') neglect of the maintenance of existing supplies in favour of focussing on capital construction and expansion.
- poor management and overlapping responsibilities within projects and agencies, diverting funds away from O & M.
- inappropriate design and technology choice, often caused by a lack of community involvement in project development;
- inadequate access to data and field experiences about O & M for use in planning O & M strategies.
- insufficient funds and misuse of funds earmarked for O & M, restricting availability of spare parts and tools, and recruitment and training of competent staff.
- inappropriate management at community level.

Trends :

Governments and external support agencies, as well as communities are increasingly concerned about the importance of integrating operation and maintenance components in the planning, implementation, management and monitoring of project activities. Sector professionals are also realizing that O & M is not just a technical issue — it encompasses social, gender, economic, institutional, political, managerial and environmental aspects. The following are some of the most noticeable trends which reflect the changing attitudes towards O & M, and are leading to increased sustainability of water supply and sanitation interventions.

Water is being increasingly seen as an economic good, which implies that communities must pay for the water they use. Governments, because of heavy financial burdens and efficiency problems, are gradually changing their role as provider of services to that of facilitator of processes. Communities are thus becoming involved in selecting the type of service they want and can afford, and have increasing responsibilities, not only in operation and maintenance of their water supply systems, but also in the financial management of these systems. Actors such as private entrepreneurs from the informal and formal sectors are also becoming more involved in operation and maintenance. At all levels, more integrated O & M strategies are being developed, in which the concerns of safe water, sanitation, hygiene education and waste disposal are tackled simultaneously. Women, as the principal users of (rural) water supplies, are playing an increasingly prominent role in management and maintenance activities. Greater attention is being given to appropriate and affordable technology, with easy maintenance, in-country manufacturing, durability, standardization and low capital and recurrent costs being the chief criteria. Finally, donor and national policies are showing evidence of due attention to O & M, with water tariff adjustments and revenue allocations in support of O & M by national governments, and, on the part of donors, well-defined policies to ensure that O & M is a central concern of the projects they support, and promotion of measures to assess O & M problems and solutions.

(Ref. : Water Newsletter No. 236/237 October 1995 page 1-2)

6

Asbestos Cement and the environment

A product is said to be 'Environmentally acceptable' when its negative impact on the environment from the manufacturing stage to usage is minimal or negligible. Further, the risk arising from such an impact is socially acceptable because it is felt that in comparison with other better known risks, this particular one is so low that no further control is justified. The criteria adopted routinely to assess the possible impact of products and technologies on the environment are :

- Energy, consumption, — Service Life — Source materials.
- Risks in production process — Risk associated with product use.
- Risk in transport, storage and disposal.

An environment friendly product is one which :

- Is produced with low energy consumption
- Has a long service life
- Is made from few simple starting materials

- ○ Presents a relatively low risk
  - ○ When manufactured
  - ○ When used
  - ○ When transported, stored and disposed of.

Lower energy consumption means lower environmental impact. Studies show A.C. products as having by far the lowest index of energy content. For example, A.C. Corrugated Sheet is about four times less energy consuming than aluminium profiled sheet — and twice less than steel sheet. Metal (steel) pipes consume five times as much energy as compared to A.C. pipes.

Short service life of a product means more frequent replacement and consequently more production cycles, with the associated energy consumption and other possible impacts.

☆ In the case of A.C. products, decades of experience world wide has demonstrated their remarkable and unique resistance. In fact, few other manufactured products have such a proven long service life (over 60 years).

☆ A.C. products are made from few simple raw materials, with simple manufacturing technologies, implying fewer and simpler controls. Risk of mishaps is, thus, negligible and managable.

☆ A.C. product manufacturing is a straight forward and simple technology. Engineering controls are also simple and can be easily put in place to maintain the asbestos dust levels well within the PELV, ie, to prevent emissions beyond permissible levels in the work place and in the outside environment.

☆ In A.C. products, asbestos fibre is firmly 'locked-in'. Fibres, thus, cannot escape into the atmosphere. Unlike other construction materials, A.C. products do not release any toxic fumes and gases into the environment during a fire. A.C. products are resistant to heat and fire; in fact, they actually prevent or minimize the spread of conflagration, thus preventing environmental damage.

A.C. products can be transported and stored with minimum care; unlike other products, they do not require any special precaution. Waste management is simple and straight forward and does not require any costly equipment or technology. Disposal of waste by recommended practices does not lead to environmental pollution.

(Ref.: Asbestos News — Vol. 2 Issue No. 1, 1996)

7

Effect of pressure and nozzle size on drop size distribution from agricultural sprinklers

Mr. Jaspal Singh & Jaideep Jhawar

Sprinkler irrigation is a pressurized irrigation system which tends to simulate the rainfall, but in such a way that the runoff and deep percolation losses are avoided and with care being taken that the uniformity of application is close to that which could be obtained under rainfall conditions. Sprinkler system works under conditions where water under high pressure is forced through a nozzle of small diameter. The issuing jet of water therefore has a very high Reynold's number which creates a considerable amount of eddies within it due to turbulence. As the jet leaves the rigid boundaries of the nozzle, the eddies tend to break the jet which is further assisted by the air resistance. This results in jet disintegrating and being converted into a large number of independent drops which fall under gravity like rain.

Water droplets falling from sprinkler irrigation play a vital role in splash erosion of soil and surface sealing, leading to reduced intake rate. Pressure and nozzle size play an important role with respect to droplet size falling at different radial distances from the nozzle and also with respect of the volumes of water being received upto specific size of droplets.

A study of droplet size distribution with respect to distance from the sprinkler was conducted on the demonstration farm of the College of Technology and Agricultural Engineering, Udaipur. The variables under study were the nozzle size and pressure. Three circular bore nozzles of 5.556 mm, 5.159 mm and 4.365 mm diameter were taken under three pressures 1.4kg/cm^2, 2.4kg/cm^2 and 3kg./cm^2. Flour method was used for determination of drop size distribution for which a calibration curve between dry flour pellet weight and water drop diameter was developed to convert the weight of the resulting dried flour pellets into equivalent drop diameters.

Conclusions :

Following conclusions were drawn :

1. The mean drop diameter increases with distance from sprinkler.
2. Mean drop diameter as well as range of mean drop diameter decrease with increase in pres-

sure and decrease with decreases in nozzle size.

3. Pressure and nozzle size have little effect on the mean droplet diameter in the neighbourhood of the sprinkler but at greater distance the effect of nozzle is quite significant.
4. Sprinkler of smaller size nozzle for the same operating pressure results in a smaller percentage of total water being applied as larger droplets as compared to smaller diameter drops.

Mr. Jaspal Singh,
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and

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Deptt, of Soil & Water Conservation Engg.
College of Technology & Agricultural Engg., Udaipur.

(Ref. : Page No. 180 — October-November, 1995 of Indian Journal of Power and River valley development)

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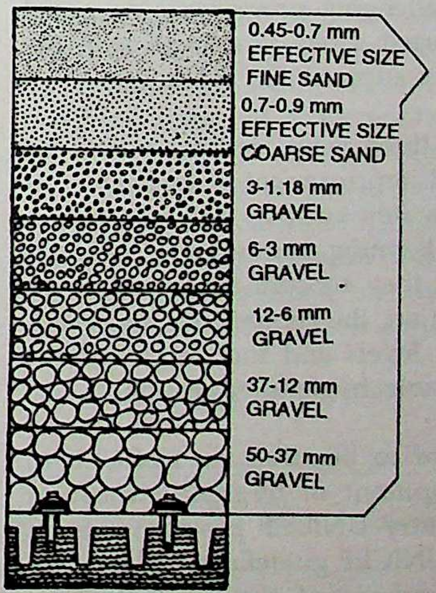

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BOOK REVIEW

Title : Hygiene Education in Bangladesh
Author : Marieke Boot, (International Water & Sanitation Centre)
Publishers : UNICEF — New York, N. Y. U.S.A.
Copy right : 1955 — United Nationas Children's fund.
Programme Publication,
3 U. N. Plaza New York,
N. Y. 10017 — U.S.A.
Pages : 107 — Soft bound.

It is widely recognised that hygiene education and hygiene behaviour change are essential if water supply and sanitation programmes are to achieve maximum health benefits. However, the inclusion of hygiene education and communication activities within water and sanitation has frequently been uncoordinated and poorly documented.

This book describes a case-study which presents an overview of hygiene education in Bangladesh. The overview includes both hygiene education activities related to water and sanitation interventions and hygiene education activities in schools and nonformal education settings. In addition, the case-study covers the challenging programme on social mobilization that started a few years ago with the aim of creating mass support for sanitation.

It also identifies three main learning points for the development and improvement of hygiene education as part of water supply and sanitation programmes. These learning points are closely related to one another; they concern the effectiveness of the hygiene education, the competence and availability of staff at all levels and the organizational structure for sustainable hygiene education.

These studies are to be used by UNICEF to assist in the development of hygiene education guidelines for in-country UNICEF programming. It is intended that the UNICEF guidelines will contribute towards development of the joint strategy (UNICEF-WHO, 1993) and I am sure that they will be also useful to governmental and voluntary organisations working in this field in developing countries of the world.

Title : History of Fluvial Hydraulics
Author : Dr. R. J. Garde
Publisher : New Age International (P) Ltd.
(Formerly Wiley Eastern Ltd.)
128A, Noorani Bldg. Block No. 3
1st floor, L. J. Road, Mahim,
Mumbai-400016.
Pages : 140, Hardbound, Price : Rs. 375/-.

Ancient civilisation of countries like China, India, Mesopotamia, Egypt and Greece grew and developed along the banks of the major rivers of those countries. The occupation of people was farming of lands with the use of river water. With increase in cultivated areas, need for irrigated agriculture arose and as a consequence, canals to transport water were constructed by building weirs and dams across the rivers. Thus study of ancient civilisations reveals that people at that time must have had sufficient knowledge about the behaviour and the laws which govern the flow in rivers. In other words people of ancient civilisation had knowledge of fluvial hydraulics which is Hydraulics of rivers flowing through non-cohesive materials.

The present book, History of Fluvial Hydraulics by Dr. R. J. Garde is an authoritative compendium on the subject and it will be very useful to the students and the research workers in the area of sediment transportation.

The presentation has been divided in seven different periods and developments during these periods have been elaborately discussed. In the last chapter, important landmarks in Fluvial Hydraulics have been listed and even guidelines have been indicated for research workers in sediment transport by mentioning the areas in which further research in this field could progress.

The historical beginning of this study has been traced in India from Vedic times when the ancient sage Bhrigu wrote his Shilpa Samhita, a treatise on planning and construction of canals, dams, wells and buildings. It is believed that sage Bhagirath, brought the mighty Ganga river from Kailas (Himalayas) to the plains and he could not have accomplished this task without adequate knowledge of river behaviour and laws which control the flow of water. In China, the Yellow river which carries water with high sediment content has been a subject of study since ancient times. The Chinese emperor, Yau and his son, Yu had succeeded in bringing many troubled rivers under control more than 4000 years ago. Similarly in Mesopotamia, King Ur-Nina had constructed canals for irrigation purposes way back in 1900 BC. There is evidence to indicate that people at that time knew planning and layout of irrigation canals and fixing of boundaries of fields by proper surveying and methods of reclaiming lands. In Egypt many irrigation structures were built in the Nile basin around 3000 BC. The Book lucidly mentions this historical review which is quite interesting to read.

Much progress in the understanding of sediment transportation was however, made during the later part of 18th century and the 19th century. It was French engineer Paul du Bays who for the first time used shear stress on channel bed as a flow parameter and provided equation for rate of bed load transport. Around the same time French Engineer Antomie Chezy presented his famous equation :

$V = C \sqrt{RS}$ which is used even today as the basic law of gravitational flow.

In early part of this century, lot of work on sediment transportation has been done in USA, UK and India. The concept of stable channels presented by R. G. Kennedy and later improvements made by Gerald Lacey are considered as significant contributions in the design of irrigation canals in alluvial soils. Similarly works done by H. A. Einstein Kalinske, Vanoni, Emorry Lane, Rouse, Iwagaki and many others in sediment transportation and sediment measurement are quite significant. The book mentions about the contribution of all these workers in proper sequence in order to indicate the systematic development in the subject.

There could not have been a better person than Dr. Garde who has himself done considerable research in sediment transportation along with his students and colleagues at the University of Roorkee for over three decades, to write this authoritative volume on Fluvial Hydraulics. The author is to be complimented for his efforts in acknowledging the contribution of almost all the research workers in this field. Wherever possible the author has presented photographs of these workers along with some of his personal particulars as well. The list of over 300 references, a detailed author index and an exhaustive subject index at the end of the book indicate the quantum of work put in by Dr. Garde in compiling the valuable book.

It will not be out of place to mention that the publishers, by presenting the sketch of king Yu of China who did pioneering work in taming the troubled rivers of China, on the cover page, have shown ingenuity and concern for river engineering.

I have no hesitation in recommending this book to all river engineers and to all those who are doing research in sediment transportation. It will be a valuable addition to all the engineering college libraries.

Reviewed by :

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Mumbai-400102.

SYNOPSIS OF PAPER PUBLISHED IN OTHER TECHNICAL JOURNALS

Use of polymers and inorganic chemical grouts in the rehabilitation of structures.

S. K. Manjrekar

Grouting is one of the age old tools which is becoming more and more useful with the progress in material science. A large spectrum of new materials — organic polymers as well as inorganic chemicals — are being used in structural and non-structural repair of concrete structures. An attempt has been made in this paper to discuss the properties and types of grouts, the application techniques and economics in relation to the selection of appropriate repair material. Case studies in rehabilitation of a few heritage structures alongwith other structures have also been presented.

(Ref. : The Indian Concrete Journal, November 1995, page-613)

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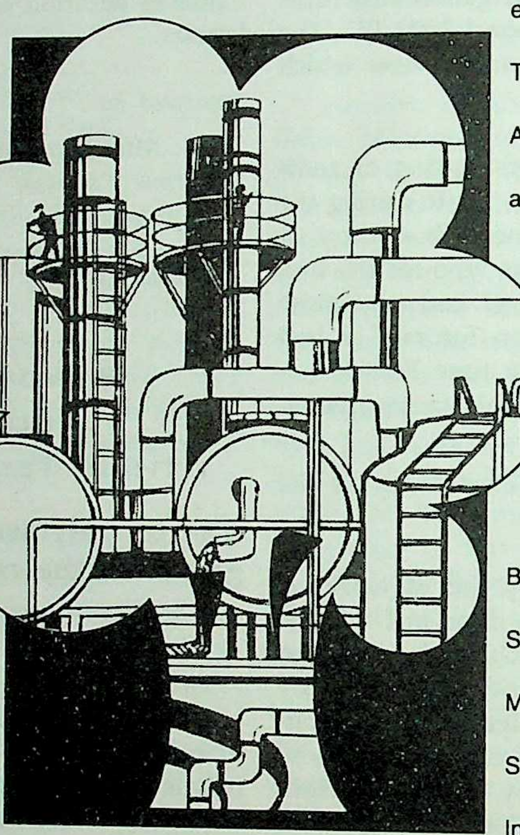

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SYNOPSES OF PAPERS PUBLISHED IN OTHER TECHNICAL JOURNALS

Optimal Control of Water Resources using Block Pulse Functions

A. N. Srivastava, Non-Member
and
R. B. Mishra, Non-Member

Optimal control and management of water resources system have received considerable attention in recent years. Various models are developed and different techniques, particularly dynamic programming, are applied for the solution of these problems. In this paper, a linear optimal regulator problem is formulated based on the dynamic Leontif model, which takes into account the supply-demand conditions. For water regulation purposes, a quadratic performance measure is utilised. Thus, the problem of management for optimal utilisation in a water resources system is transformed into a standard linear quadratic optimal control problem. The solution is obtained by block pulse functions method.

(Ref : Journal of The Institution of Engineers (I), Civil Engg. Divn. Vol. 74, August 1993, Page 60)

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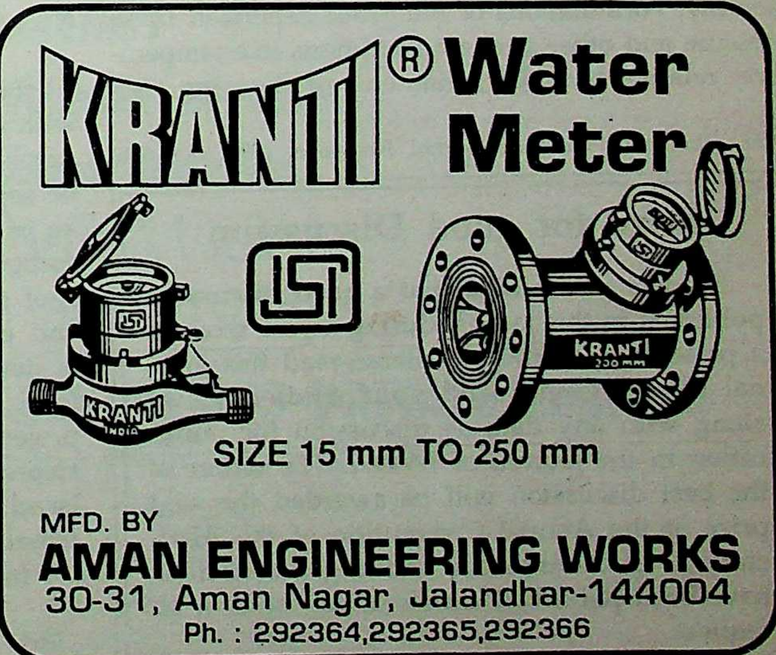
A Review of Techniques in Groundwater System Analysis and Recent Trends

Dr. A. K. Rastogi, Member

Use of groundwater is continuously increasing in many parts of the world today to meet the ever-growing industrial, agricultural and municipal demand for water. Excessive stress on aquifers has led to the problems of critical lowering of water table, seawater intrusion in coastal aquifer, land subsidence and water quality deterioration in many countries today. As a result, systems approach to groundwater resources is used to investigate various groundwater flow problems. This paper examines the techniques of studying the response of system to various schemes of groundwater withdrawal from the aquifer system. It considers the advantages and limitations of these techniques, eventually emphasising on the recent trends of groundwater management models involving the principle of linear and non-linear optimisation. Finally, the paper concludes that though development in the techniques of solution must be kept in mind, however, due to excessive complexity of real life issues, the groundwater systems approach alone is not enough to solve real world problems.

(Ref : Journal of the Institution of Engineers (I), Civil Engg. Divn., Vol.74, August 1993, Page 69)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NEW PRODUCTS & PROCESSES

Repairs to leaking socket and spigot joints of prestressed concrete pressure pipes

The joints in concrete pressure pipes sometimes leak due to inaccuracies in dimensions of sockets and spigots. In case of prestressed concrete pipes, due to the flexible nature of its joints, normal caulking with cement mortar fails to prevent leakage.

Polysulphide or silicon-like sealants can be useful in such joints but the high cost of such material does not make it economical since there are innumerable joints in a pipe line and prevailing wet conditions grout (PCG) which is very flexible in nature and fully compatible with concrete proved very effective and useful for such joints. Many a joint in several kilometre long pipeline has been successfully attended to by this grout in different parts of india where diverse climatic conditions exist.

Earlier, in case of such leakages water supply through the pipelines had to be stopped in order to carry out the rectification. However, the above mentioned method of grouting these joints and then caulking the elastic polymer cement mortar even in damp conditions proved very useful and successful on several occasions. If the running water pressure was very high, say of the order of 8 to 10 kg/cm², then the same was brought to reasonable level of operation of 3-4 kg/cm² at which the grouting and caulking operations were done quite satisfactorily. Formulations of the grout depended upon pressure and other ambient conditions like temperature, relative humidity, diameter of the pipe etc.

(Ref.: The Indian Concrete Journal, November 1995, page-618)

Prize for good Discussion

Readers please note that a good discussion published in this journal during a year receives a prize of Rs. 200/-. So please read this journal carefully and send your studied views along with any data as discussion for publication in the journal of IWWA. The writer of the best discussion will be awarded the said prize at the Annual Convention of the Association. Guidelines for sending discussions have been published earlier or can be sent on request.

Notes & News

Fern absorbs metal wastes

Researchers at the Hebrew University of Jerusalem's faculty of agriculture in Rehobot have found that a fast-growing plant, the azzola fern, can be harnessed to absorb radioactive wastes as well as prevent the loss of precious metals in jewellery manufacturing processes.

Dr. Motti Sela, of the faculty's department of botanical agriculture, explains that the fern — which doubles its mass every three days — lives among blue-green algae that bind carbon monoxide. The fern does not require fertilisation and can develop not only in potable water, but also in partially treated sewage water, Dr. Sela said. It grows naturally in many places throughout the world, including South East Asia, North and South America and Egypt.

Sela found that the fern is capable of absorbing several poisonous heavy metals including lead, cadmium, nickel, zinc, mercury and chromium — through its roots. Further investigation showed that the plant, in its dry or wet state, is also capable of absorbing uranium, a problematic radioactive waste from nuclear reactors. This phase of research was carried out in cooperation with the Israel Atomic Energy Commission's Soreq Nuclear Research Centre. It was also discovered that not only did the living azzola absorb these problematic wastes, but dried azzola absorbs the metals in amounts of upto 6% of the plant's weight.

Further research showed that when blended with a mixture of precious and common metals, the azzola acted like a sponge and various metals could be separated. The research team found that from 1 kg of dry azzola plant, it is possible to extract absorbed precious material in quantities such as 4.8 g of gold, 6.13 g of platinum and 18 g of the rare and precious metal, palladium. The research team is developing a special filter for using the azzola fern in various environmental and industrial projects. Based on the results of the research, the Hebrew University has patented the dry azzola in Israel and other countries. A University spokesman remarked that the patent had generated great interest from industrial firms.

(Ref: World Water Developing World Bulletin, Issue 2, 1993, Page 24)

Peoples project for recharge augmentation

Ground water table in Gujarat state in Western India is going deeper and deeper, especially in Saurashtra area — a basaltic terrain. To counter this, Swadhyay Parivar, a voluntary agency started by Hon'ble Pandurang Shastri Athavale (Alias Dada) is motivating thousands of farmers in Junagad and Rajkot Districts of Saurashtra to recharge their dug wells with clean run-off water during and after Monsoon rains.

After 1960, there had been a tremendous spurt in the number of diesel and electricity-driven pumps for drawing water for irrigation, while the replenishment was at the same rate as it had been for centuries. A direct result was that the groundwater levels all over Gujarat have shown a rapid fall in the past 25 years.

The utilisable groundwater recharge in Saurashtra region is put at 4289 million cubic mtrs per year and the net groundwater extraction from wells is estimated at 2186 million cubic mtrs a year, leaving a balance of 2103 million cubic mtrs. only. The situation has been further compounded by the erratic behaviour of the south-west monsoon in the past 17 years. The average rainfall for the past 17 years in Junagad Dist., worked out at 805 mm or 31.7 inches. But more important was the fact that only in 6 of these 17 years was the rainfall above average, while in the remaining 11 years, it was below the average. Recharging of a well used either for irrigation or drinking water supply, envisages a rather simple action by the villagers themselves — of impounding or arresting water of the meagre rainfall from running away and turning it into the bore wells or dug wells.

(Ref. : AGID's South & West Asian Geoscience News Letter 28th & 29th issue July & Nov. 1995, pages 5 & 6)

World Bank Roundup

The International Development Association (IDA) on December 19 approved a credit of dollar 290.9 million for a project to improve water management, planning and development in the eastern Indian state of Orissa. Eighty seven percent of the state's population lives in rural areas and agriculture accounts for 44 percent of GDP in Orissa. The funds will help complete ongoing projects, rehabilitate and modernize selected existing irrigation schemes, increase and improve institutional capacity for planning, investments and management; and foster research, technology transfer and agricultural intensification in the water sector. The project includes support to resettle and rehabilitate people displaced by project works.

(Ref. : WBN December 22, 1995 page 6. Volume XIV. No. 45)

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16 Sewage Treatment Plants for Delhi

The Delhi Government has prepared a Rs.300 crore plan to set up 16 sewage treatment plants at different points to prevent pollutants flowing into the Yamuna river. The work orders for 13 out of 16 plants have already been given to seven parties. The first such plant at Okhla with a capacity to treat over 260 mgd of waste water was inaugurated on July 25. The land for the proposed 13 sewage treatment plants has been acquired and efforts are on to get land for the remaining three plants. Work on the three plants at Keshopur, Rithala and Mehrauli is pending as additional land of 100, 80, and 10 acres is required.

(Ref : Civil Engg. & Construction Review, Sept. 1995, Page-5)

Indian Trust to provide drinking Water

The Sri Sathya Sai Central Trust of India has undertaken a Rs.175 billion project to provide drinking water to the people of Anantapur district in Andhra Pradesh, within one year.

The Anantapur project would benefit over 900,000 persons spread over 700 villages. For the past 15 years, the people of the area have been facing an acute shortage of drinking water because of scant rainfall. Groundwater in many parts of the district has been found to have a high fluoride content.

The trust has over 1,500 centres in 135 countries. It plans to undertake similar projects in Chittoor and Nellore districts in a phased manner. A drinking water supply scheme covering 70 villages is being implemented in Maharashtra.

(Ref. : Asian Water & Sewage, Nov.-Dec. '95, Page-8)

World Bank Funding for Mumbai Sewage Project

A US $ 295 million World Bank financed project will build on a previously constructed sewage collection system in Mumbai to address the treatment and disposal of waste waters in the city. The project includes construction of two sea outlet tunnels and one pumping station, (each tunnel will be 1.8 mile long and will discharge 800 million litres per day), construction of two aerated lagoons and a slum sanitation programme to serve one million people. Once completed, some 80-90 per cent of the buildings and 15 per cent of the population of Mumbai will be connected to a sewage collection system, bringing significant improvement in health and quality of life.

(Ref. : Civil Engg. & Construction Review, Nov. 1995, Page-6)

Gujarat likely to be hit by water problems

The municipal administration has been battling in a no-win situation in the former princely city of Jamnagar, once known as Paris of Saurashtra, where water supply is fast dwindling.

Apart from 'selling' water to industrial and commercial consumers at commercial rates, the municipal authorities have imposed a severe cut in water supply to domestic consumers. Municipal taps remain dry for three days a week in the city. As against the demand of 1.70 crore gallons of water per day, the city gets just half of it.

The authorities have been toying with the idea of discontinuing water supply to industrial units and commercial consumers from March next year to save this precious commodity for domestic consumers.

In Rajkot, the situation is slightly better than in 1986 when the state government had to run 'water special trains' from Gandhinagar to the former capital of Saurashtra to meet the worsening situation, besides preventing unorganised mass migration to neighbouring cities and towns.

But even today, drinking water is supplied only on alternate days and that too for 20 minutes only. The situation in the nearby towns and villages is also threatening to go out of control and many fear that it might lead to a 'water riot'.

Due to drastic fall in the flow of water from the Dharoi irrigation project, now tied up for drinking water supply to Gandhinagar, the Ahmedabad municipal corporation has been forced to discontinue water supply in the evening. Fast evaporation and diversion of water for irrigational purpose has forced the district collector to ban the use of water for irrigation by farmers on the 140-km-long stretch from Dharoi to Ahmedabad.

Because of scanty and irregular monsoon, the state government estimated that nearly 59 urban centres and 5,243 villages face shortage of drinking water.

(Ref. : Times of India, Bombay, 11-12-1995)

FOREIGN NEWS

Unique drinking water plant goes on-line in U.S. State of Maine

The Portland Water District's innovative new water treatment plant began operation in early February 1994, delivering treated water from Sebago Lake to the District's 170,000 customers. It is the largest ozonation plant in New England, generating 1,300 pounds of ozone per day, and the first in the country to use 'Free-standing' ozonation without filtration for primary disinfection of a surface water supply.

The new $ 18.6 million facility will bring the District's drinking water into compliance with the U.S. Environmental Protection Agency's newest regulations under the federal Safe Drinking Water Act (SDWA).

This successful application, the result of the exceptional purity of Sebago Lake Water and the District's already comprehensive watershed protection programme, saved the District and its ratepayers an estimated $ 20 million in capital costs — the additional amount that would have been needed to construct a new filtration plant. Ozone is a much more powerful disinfectant than chlorine, destroying a wider range of organic compounds. Moreover, ozone does not react with organic matter in raw water to form chlorinated by-products, such as, trihalomethanes (THMs) and haloacetic acids, which pose potential health threats to water consumers. Finally, ozone's strong oxidising capabilities are effective in reducing tastes, odours and colour in drinking water.

(Ref : Water & Wastewater International, Vol.9, issue 2, April 94, p.8)

Fuzzy logic applied to catchment modelling !

Multi-dimensional hydrological models for catchment simulation are quite a rarity, primarily because of the amount of computing they require. But a multi-disciplinary team funded by the German Federal Ministry for Research and Technology has found a combination of techniques to set up a simplified modelling method based on land use. A key part of the development has been the use of fuzzy logic for simulating the unsaturated flow.

The modelling team has been based around the Institute for Hydrology and Water Resources at the University of Karlsruhe under Prof. Dr. Ing Erich Plate, and has used the resources of 15 institutes of the University, plus the University of Heidelberg and the State Agricultural Research station of Baden-Wurttemberg. The co-operating institutions cover meteorology, geography and geoecology, geology and geophysics, mineralogy, satellite imagery, computer and information sciences, agriculture microbiology, water chemistry, hydrology, hydraulics and agricultural engineering.

Fuzzy sets were introduced in 1965 and have been applied to various fields, such as, decision making and control. A fuzzy set is a set of objects without a clear boundary. In contrast to ordinary sets, where for each object it can be decided whether it belongs to the set or not, a partial membership of a fuzzy set is possible.

The main advantages of the fuzzy matrix water model are its high computational efficiency — about two orders of magnitude faster than the numerical solution — its numerical robustness and its easy programming method.

(Ref : Water & Wastewater International, Vol. 9, Issue 2, April 1994, page 40)

World Conference on Water Pollution Control

Singapore will be the first South-East Asian nation, to play host to the prestigious Water Quality International 96,' — an international forum on water pollution — from **June 23-28, 1996.**

Water Quality International 96, which is the 18th biennial international conference of the highly regarded International Association on Water Quality (IAWQ), will offer an overview of the latest research on water management, pollution control, hazardous waste management, environmental protection and all aspects of water technology.

It will also focus on the viability of waste water recycling, the impact of legislation on waste management, the impact of waste management on tourism, new applications for water technology and a host of other scientific and technical issues that are relevant to the Asia-Pacific region.

In conjunction with Water Quality International 96, an exhibition on water technology, 'Aquatech Asia 96', will be also held from June 24-26 1996 at the Singapore International Conventions & Exhibition Centre (Suntec Centre).

For more information, please contact:

James Quek, Consultant,
Logos Communications,
9, Kallang Place 04-10
Singapore-339154.
Tel.: (65) 2958162 Fax: (65) 296 5588

Jenny Ong., Project Manager,
RAI Exhibitions Singapore Pvt. Ltd.,
1, Maritime Square 09-49, World Trade Centre,
Singapore-099253.
Tel.: (65) 2722250 Fax: (65) 272 6744

San Francisco plans reuse scheme

The reuse scheme calls for recycled water to be pumped into three new underground reservoirs after undergoing tertiary treatment at a proposed new plant. In addition to improving San Francisco's water resource management, the programme will improve fire protection in areas not now served by the auxiliary water supply system, a network of high pressure pipes, pumps, and reservoirs used as backup to fight large fires and supplement the city's low-pressure system.

(Ref. : Journal of A.W.W.A. — October 1995, page-113)

Congratulations ! Prize Winners

1. **Mr. I. N. Kancharadi Prize Rs.1,000/-**

   Dr. Ram Karan Singh and Dr. Shiv Prasad authors of paper 'Decomposition principle based optimisation of water Distribution system'.

2. **Best papers published in the journal during the year 1995.**

   I Prize Rs.500/- — Late Mr. P. V. Patki Memorial Prize to Mr. K. Srinivasan & Mr. M. C. Philipose for their paper 'Development of Storage-Reliability-Yield (S.R.Y.) relationships for Hemavathy Reservoir'.

   II Prize Rs.300/- to Mr. N. Suresh Nathan, Mr. G. Vijayan, Mr. R.Saisubramanian and Mr. T. Thamizhselvi for their paper 'Criteria for Rehabilitation of water mains among Viable Alternatives — a case study.

   III Prize Rs.200/- to Mr. Sudhir Bhatia for his paper 'Motivational Paralysis in operation and management of State owned water supplies'.

3. **Prize for the best discussion published — Prize Rs.200/-** to Mr. P. Mariappan for the discussion of the Optimization of pumping mains with multiple inlets'.

4. **Prize for — Best lecture delivered at local centre — Rs.100/- each**, Delhi Centre, to Mr. S. Prakash — 'Yamuna water accord'. Indore Centre to Mr. V. K. Soni 'Investigation of Soil environment along the conveyance main of Indore water supply scheme'.

   Jodhpur Centre to Dr. D. D. Ozha — 'Water Quality Awareness for Health and Agriculture'.

   Pune Centre to Mr. Prakash Gole — 'Water and Environment'.

5. **Prize for Best maintained local centre** — Calcutta centre — Cash Prize of Rs.500/- alongwith Shri S. K. Shah Memorial shield.

HINDUSTAN DORR OLIVER PRIZES

(For papers presented at the 28th Annual Convention of IWWA, Jodhpur, 12 to 14th January 1996.)

I Prize Rs.500/-

To Sarvashri Singh R. V., Vinod Kumar, Meenakshi and Dr. Ram Gopal for their paper 'Possible source of high nitrate levels in ground water of Churu district of Rajasthan'.

II Prize Rs.300/-

(a) To Sarvashri Paliwal S. C., Sharma D. C. and Jain P. C. for their paper 'Ground Water Resources of Western of Rajasthan — Project and problems.

(b) To Mr. B. J. Vasavada for his paper 'Reverse Osmosis plants for desalination of water — a case study'.

III Prize Rs.200/-

To Shri Bhardwaj D. C. for his paper 'Beneficiary involvement in water supply projects.

A special prize was given to Dr. Costonico Falliace (a consultant from Italy) for his paper 'Rengeland development and management in arid and semi-arid lands (specific reference to East African conditions)'.

system to provide underground tunnels as wide as highways, and 60 to 100 m below ground.

Singapore is currently served by a network of sewage pipes measuring 2,450 km in length. These pipes carry sewage from 134 stations to six treatment plants.

The proposed tunnel system comprises deep cross-island tunnel sawers, networks of linked sewers to transport the sewage to the main tunnels, one or two centralised sewage treatment works and deep sea outfalls which will discharge the treated wastes far out to sea. The system, if implemented, will either complement or replace partly the existing network of sewers and treatment plants. ENV is also in the midst of a S $1.4 billion (US $1 billion) five year development programme to maintain and upgrade the sewerage system.

This project will be the first major project involving the use of underground caverns and deep tunnels in Singapore. By going 60 to 100m below sea level, the system will make use of the best rock conditions.

(Ref. : Asian Water & Sewage, April '96, Page-4)

World Bank approves millions for India's water and sewerage projects

India: India has obtained approval from the World Bank for a loan of US $ 192 million and US $ 142 million for Mumbai's sewerage disposal project and hydrology project, respectively.

The first project aims to increase the capacity of Mumbai's management of the provision of sewerage services.

The other objective is to sustain the financial viability of the provision of water supply and sewerage services through direct charges to beneficiaries at appropriate levels. Total project cost is US $ 295.6 million. The US $ 142 million loan for a US $ 162 million project will assist the Indian government and seven participating states to develop comprehensive, accessible and user-friendly database covering all aspects of the hydrological cycle.

This includes surface water and groundwater in terms of quantity and quality and climatic measurements. The project will also support the objective of the National Water Policy.

(Ref. : Asian Water & Sewage, April '96, Page-4)

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Foreign News

Characteristics and costs of MF and UF plants

A questionnaire was sent to full-scale membrane filtration plants worldwide asking about capacities, operation, water quality and costs. Seventy four responses were received. The total plant capacity of all utilities responding was 36 mgd (136,800 m^3/d for UF and 13 mgd (49,400 m^3/d) for MF. About 90 percent of the existing plants have design capacity 1 mgd (3,800 m^3/d). Only three plants — two UF and one MF — have capacities 5 mgd (19,000 m^3/d). These plants were installed in 1994 or are currently being commissioned, which suggests that MF and UF plants with capacities 5 mgd (19,000 m^3/d) have just recently become technologically and economically feasible.

The source of waters for the plants included both groundwater (35 percent) and surface water (65 percent). The source waters were not necessarily limited to high-quality waters. In 40 percent of the plants, feedwater turbidity was 10 ntu. Although influent total coliform concentrations ranged from 1 to 1,000/100 mL, none of the plants reported the presence of coliforms in their permeate.

MF plants appear to be operated at a higher flux than UF plants. The higher operating flux of the MF membranes seems to accelerate the irreversible fouling rate of the membrane, requiring more frequent chemical cleaning for MF than for UF membranes. Plant residuals are being disposed of in various ways. Thirty to 35 percent of the plants are recycling the backwash and chemical cleaning waste to the source water.

Treatment unit cost for membrance filtration plants ranges from \$ 0.50/1,000 gal (\$ 0.13/m^3) to as high as \$ 2.5/1,000 gal (\$ 0.66/m^3), depending on plant capacity. For example, the current treatment unit costs (capital plus O & M) by MF process with capacities of 0.1 and 1.0 mgd (380 and 3,800 m^3/d) are about \$ 1.12/1,000 gal (\$ .30/m^3) and \$ 0.56/1,000 gal (\$ 0.15/m^3) respectively. Because of the rapid development in membrane filtration technologies, their capital and O & M costs are expected to continue to decline, further endorsing the use of these membrane treatment techniques.

(Ref.: Journal American Water Works Association, May 1996)

MWSS announcess privatisation of Manila's water utility

Philippines — In April 1996, Manila's Metropolitan Waterworks & Sewerage System (MWSS) has approved International Finance Corp's (IFC) proposal to privatise two largest water utilities. This entails the break-up and auction of the facilities. The IFC also called for at least US \$ 5 billion in investments to modernise water distribution around Manila.

(Ref. : Asian Water & Sewage, June 1996, Vol. 12, No. 5, Page 6)

Depleting groundwater — a problem in Bangladesh

Bangladesh is threatened by depleting groundwater and experts fear massive crop losses and collapse of urban infrastructure in the country.

Northern Bangladesh is the worst hit, with groundwater level dropping by 21 m since the start of the dry season. Officials said that the groundwater level there has fallen beyond the reach of deep water suction pumps, while a number of small rivers have dried up.

The adoption of crop diversification programme has increased the use of irrigation water and about 70% of water is drawn from the subsoil level. The Ganges-Kobadak Irrigation project in the western district of Kushita has virtually stopped because of water shortages, threatening 300,000 acres (120,000 hectares) crops.

This unusual shortage of water has proved harmful to industries. A paper mill in northwestern Pabna district, for example, failed to work and was shut down. It has been learnt that the Sunderbans, the world's largest mangrove forests, have been affected by the depletion of water. In the urban areas, especially in Dhaka, groundwater level is falling 2.3 ft every year.

(Ref.: Asian Water a Sewage, June 1996, Vol. 12, No. 5, page 9)

Singapore considers underground Tunnel sewer system

The Environment ministry (ENV) in Singapore is considering the construction of a new sewerage

Notes & News

Global Urban Growth Accelerating — Report Says Unprecedented Impact on Resources is Forecast

By 2025, the world's population is expected to increase by 50% reaching 8.3 billion, and two-thirds of humanity will be living in cities, according to a report by three top international organizations and a leading think-tank, the World Resources Institute.

The report, World Resources 1996-97, warns that urbanization has become one of the most critical global trends of the future and could pose a serious threat to the quality of life and the environment throughout the world.

Humankind could have more impact on the Earth's biological, geological and chemical systems during our lifetime and our children's, than all preceding human generations put together, said Maurice Strong, chairman of the World Resources Institute. The report, published with the World Bank, the UN Development Programme and the UN Environment Programme, points to some positive trends, but overall finds that greater environmental challenges lie ahead unless the human race changes its course:

By 2015, the world will have 33 megacities with populations of more than 8 million, and more than 500 cities with populations of 1 million or more. Every day, more than 150,000 people are being added to urban populations in developing countries.

By 2000, the physical size of cities in developing countries is expected to double what it was in 1980, exerting phenomenal stress on local environments. Half the world's coastlines and coastal ecosystems are already at risk from development.

In coming decades, most of the world's poor will be urban, living under conditions that can be worse than those of the rural poor. The number of urban poor in Latin America alone increased from 44 million to 115 million between 1970 and 1990.

By 2020, energy use will increase by 50 to 100 percent. Emissions of greenhouse gases that contribute to the risk of climate change will increase by 45 to 90 percent. The number of motor vehicles could grow to more than 800 million by 2010, exacerbating urban air pollution, especially in rapidly industrializing countries.

By 2050, as many as 2.4 billion people, nearly one-fifth of the world's projected population — could live in countries facing water shortages. In 1994, at least 220 million urban dwellers lacked steady access to safe drinking water, fully 90 percent of sewage in developing countries goes untreated.

Food production is expected to keep up with population growth but many people will still go hungry; by 2010, the number of Africans who suffer from malnutrition is expected to increase by 70 percent, to 300 million.

(Ref : World Bank News, April 18, 1996 page 4)

* * *

Taxing Bads by Taxing Goods

The notion of taxing polluters has been around almost as long as pollution itself. The first such recommendation in fact was made in Pigou's Economics of Welfare in 1920. But fees on polluters have not been applied as much as regulations, which experts argue are unnecessarily costly. A new study by the World Bank argues that taxes on polluting inputs and on outputs can be very important measures in cost effective pollution control programs. A combination of instruments, some that reduce output in polluting activities and others that reduce emissions per unit of output — can mimic the effect of an optimal emission fee, but with less monitoring.

Pollution Control with Presumptive Charges uses examples from Mexico City, Chile and Indonesia to illustrate the choice between policy instruments and how they work together. Demand for polluting goods and services can be manipulated to reduce pollution through taxes on polluting goods and inputs.

Failure to employ gasoline taxes in Mexico City, for instance, would increase the costs of pollution control. In Chile and Indonesia taxes on the dirtier fuels could alter significantly the fuel mix of industries, making production less polluting with lower costs for monitoring and enforcement.

(Ref. : World Bank News April 18, 1996 page 5)

* * *

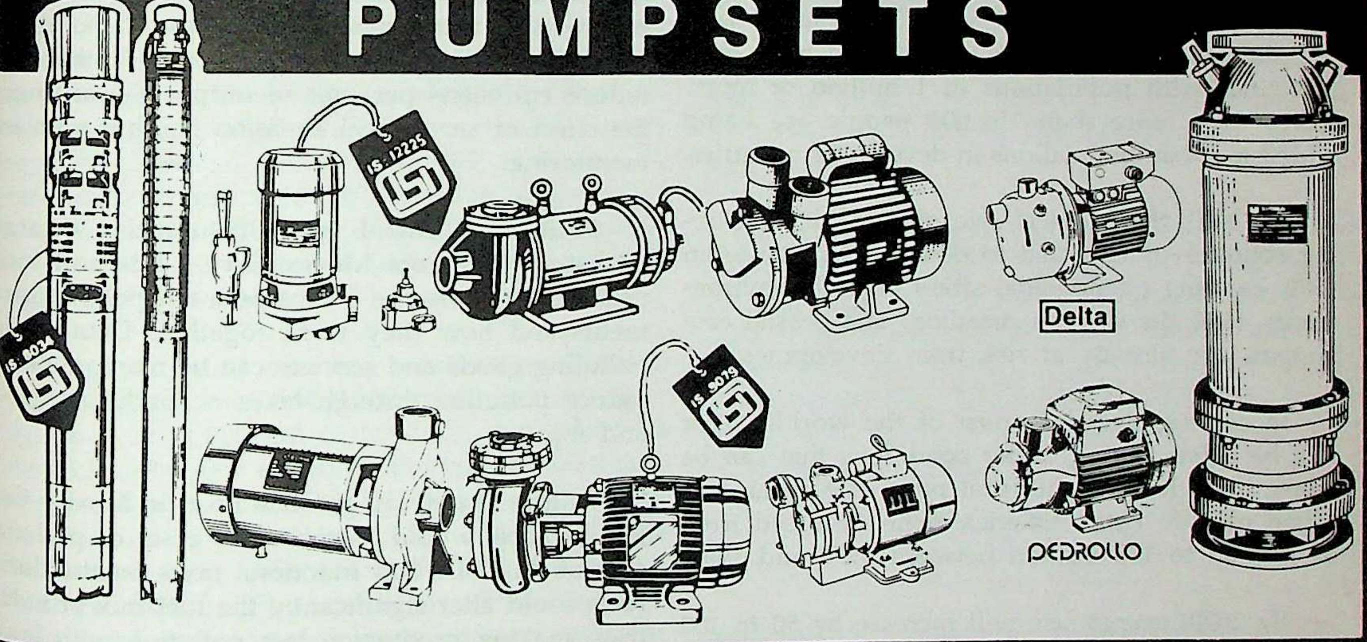
Abstracts of papers published in other Technical Journals

Sand-based filtration/adsorption media

M. Mansoor Ahammed and M. Chaudhuri, Environmental Engg. Laboratory, Department of Civil Engineering, Indian Institute of Technology, Kanpur-208016.

With a view to developing filtration/adsorption media for use in low-cost household water purifiers, a laboratory study was undertaken to assess the potential of sand coated (impregnated) with hydroxides of iron, aluminium, calcium, or magnesium in removing bacteria, viruses and turbidity from water. In short-duration (1 h) downflow column tests (bed depth 15 cm. filtration rate 0.9 m/h), coated sand showed better performance than plain sand in removing spiked Escherichia coli and indigenous heterotrophic bacteria from a canal water. Iron hydroxide-coated or iron and aluminium hydroxide coated sand showed the best performance in terms of bacteria and virus removal. They removed 80-84% of heterotrophic bacteria (influent concentration 700-850 CFU/mL) from raw canal water (pH 7.8-8.1; turbidity 12-15 NTU), and 94-96% of spiked E. coli (influent concentration 450-750 CFU/mL) from filter sterilised canal water in two sets of column tests. Filtrate turbidity remained in the range of 1.1-1.4 NTU Virus column tests, using filter-sterilised canal water spiked with poliovirus 1 (influent concentration 5.2-8.0 x 10^6 PFU/L) showed 73-87% virus removal by these media. In long-duration (2 months) column tests using the two coated sand media, mimicking the use pattern of household water filters (2 h in the morning and 2 h in the evening) a substantial improvement in aesthetic and microbiological water quality was observed when sewage-spiked canal water (pH 7.8-8.2; turbidity 16-45 NTU; faecal coliforms 170-350 MPN/100mL; heterotrophic bacteria 1400-3900 CFU/mL) was used as influent. The effluent characteristics were turbidity 0.5/1.7 NTU, faecal coliforms 2-7, MPN/100 mL, and heterotrophic becteria 190-520 CFU/mL. The study indicated the potential of iron hydroxide-coated or iron and aluminium hydroxide coated sand as a filtration/adsorption medium for use in low-cost household water filters in rural areas of developing countries.

(Ref. : Journal of Water Supply Research & Technology, AQUA volume 45 No. 2 April, 1996 page 67)



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proper time. Even in the case of validity of the contract or granting extension of time to the agency, lapse of some paper work, sometimes, is not much important since the entire case is to be considered in light of the conduct of the parties.

The provisions of Arbitration Act (1940) & the latest ordinance promulgated by the President of India on 16-1-1996 are also included in the book.

The author has taken elaborate efforts in bringing out this book. It would be very much useful for Engineers working in various departments and so also the other staff dealing with legal cases arising out of contract. This book can be used as a good reference book by field officers to settle issues arising out of contracts.

— S. D. Sulakhe
Superintending Engineer,
MWSSB, Circle No. II, Thane-400602.

Forthcoming Events

12th National Convention of Environmental Engineers on 'Pollution Control for Sustainable Development and Human Health'

12th & 13th October, 1996 at Jabalpur

For further details write to:

The Honorary Secretary
Jabalpur Local Centre,
The Institution of Engineers (India),
Visvesvaraya Marg, Civil Lines, Jabalpur-482001.
Tel.: (0761) 321829.

Seminar on Services in Multi-storeyed Buildings

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For details write to:

Mr. Ashok Tewari, *Organising Secretary*
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School of Building Science & Technology
Centre for Environmental Planning & Technology
Kasturbhai Lalbhai Campus,
Navrangpura, Ahmedabad-380 009.
Tel.: 442 452, 442 470, Fax: (079) 442075.

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- Ground water use — innovative water supply and sanitation solutions.
- Gender issues — integrated community development.
- Balancing delivery and participation — management of resources for potable water.

BOOK REVIEW

Title : **Engineering Contracts and Arbitration**

Author : Mr. B. J. Vasavada

Publisher : Mrs. Jyoti B. Vasavada,
Jyot, 628/2, Sector 30,
Gandhi Nagar-382030.

Shri B. J. Vasavada, Executive Engineer in Gujarat Water Supply and Sewerage Board, has written a book on Engineering Contracts and Arbitration. Legal experts have written number of books on Law of contracts with detailed commentaries. Such books serve as a very good reference material for lawyers and to those who are directly connected with the legal profession and therefore cannot be used with ease by the practising engineers. Management of contract is a very important function to be carried out by the field engineers in the capacity as Project Managers. It is a well settled rule that ignorance of law is no excuse. Engineers should therefore, be aware of the frame work of the law applicable for the contracts they are managing and it is necessary to have basic knowledge of Contract Act including arbitration. The author who is a practising engineer & also a graduate in law, has brought out this book to help the fellow engineers working in Govt. or Quasi-Govt. Organisations. The book contains 13 chapters including engineering contract and its formulation, performance of contracts, extras and variations in engineering contracts, time of performance, breach of contracts, contracts for projects under international Aid, Administration and Management of contracts and Arbitration etc.

It may be noted that article 14 of the constitution of India states that the State shall not deny any person, equality before the law or equal protection of the laws within the territory of India. Though the provision exists under Article 14 that an intelligible differentiation which distinguishes persons or things that are grouped together from others left out of the group is allowed. It is however necessary that such differentiation must have a rational relation to the object sought to be achieved. In view of this, condition of pre-qualification can be imposed depending on the technical know how, working experience, professional expertise, financial capability etc. Imposing conditions for pre-qualification or inviting selective contract for a particular work is therefore not prohibited under the constitutional provisions.

Breach of contract occurs when the party to the contract repudiates the contract or the party fails to perform one or more objects, obligations imposed upon him by the contract or where a party disables himself in fulfilling his part of obligations.

The author has also dealt in details regarding the breach of contract including anticipatory breach and present breach. It may be noted that as per section 39 of the Act, when a party to contract has refused to perform or disabled himself from performance of his promise in its entirety, promisee may put an end to the contract unless he has signified by words or by conduct, his acquiescence in its continuance. Under such circumstances action can be brought immediately or one can wait till the date of performance anticipated and then take action after that date. Various illustrations about frustration of contract are also described by the Author. It may also be noted that contract of painting of picture cannot be enforced if a painter dies. Similarly in case of consultants or contractors if the nature of the work involves personal skill, contractor's death may put an end to the contract and such contract cannot be enforced with his legal heirs but the party who has gained any advantage must return it to the other party. The author has also described about the promissory estoppel and cases have been described in details. It has also been highlighted that for breach of contract claims for remote or indirect losses are not sustainable.

The principle of quantum meruit is also described in details. When the contractor has carried out a work even though express agreement is not available, the party who has gained advantage should return it to the other party by way of reasonable price. However, the Supreme Court has ruled in one case that if the circumstances which existed at the time of entering the contract are not changed, relief cannot be sought under Quantum Meruit.

It is true that various aspects of Contract Act cannot be elaborately considered in a short book and moreover to understand the legal implications legal knowledge such as evidence act etc. is also necessary. It is however, observed that in many cases when there are disputes between the contractor & the organisation the matters are not dealt with properly and effectively at the appropriate time in the office concerned. The engineers are not aware of the legal provisions of the contract act & the Divisional Accountants or Assistant Engineers who are dealing with such cases are also not having adequate knowledge for taking proper action at

Synopsis of M. Tech. Thesis with Conclusion

- Removal of Chromium (VI) from aquatic system by Salvinia rotundifolia Willd.
- By Mr. S. Ayoob, (presently working as lecturer in the department of Civil Engg. T.K.M. College of Engg., Quilon, Kerala-691005.

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Dr. A. K. Chatterji
Prof., Dept of Agriculture Engg., I.I.T. Kharagpur-721302.

During the last two decades in the arena of environmental biotechnology the use of aquatic plants is gaining ground in solving waste water treatment problems by way of reducing the pollution load. The basic principle is to exploit their metal absorption and accumulation capacity. In the present study the common aquatic weed, Salvinia rotundifolia Willd was taken to look into the possibility of its use as a 'Scavenger' of chromium pollution. The pH of the bathing medium was found to play a significant role and considerable removal took place in the pH range of 5-6.5 with a maximum at 5.50. At optimum conditions, the plant accumulated 5.501 mg of Cr/gm dry wt. of the biomass. A concentration and incubation time dependent removal kinetics was noticed. For the first 7 days, the percentage removal was 73.68, which went up to even 95.16 in a series batch study at the end of 14 days (Fig. 1) The biosorption isotherm so developed was found to be following Freundlich equation (Fig. 2).

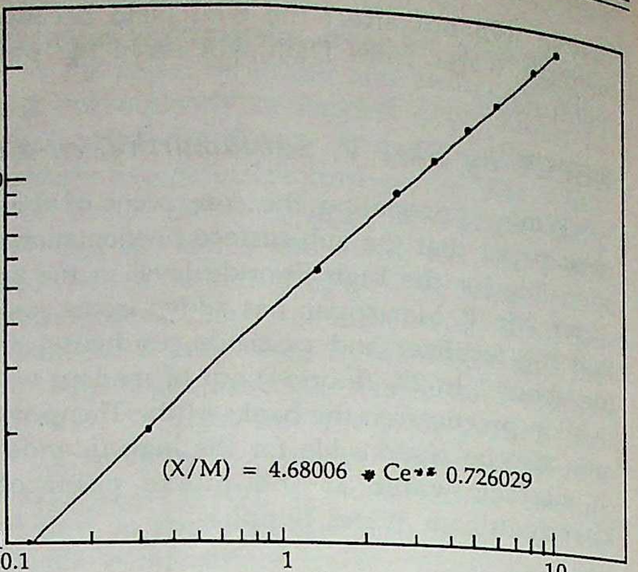

Fig. 2
The Biosorption isotherm

The weed used for chromium removal of course gets affected due to its adsorption and accumulation in it. In this study after a contact period of 7 days the biomass and chlorophyll contents of the weed were observed to have been reduced by 20.77% and 14.64% respectively while the conductivity of the plant tissue was found to have increased by 10.06%. Beyond a lethal dose of 20 ppm all these parameters had undergone sharp changes indicating their use in the monitoring of chromium pollution (Fig. 3). ❑ ❑

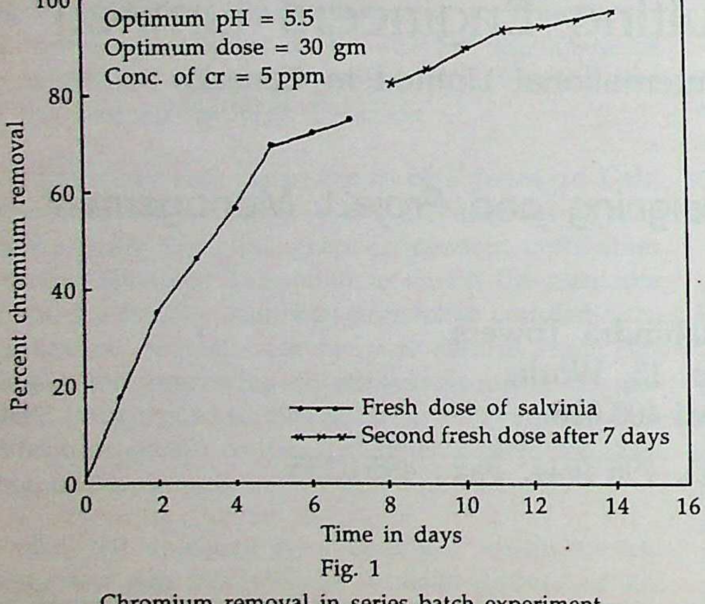

Fig. 1
Chromium removal in series batch experiment

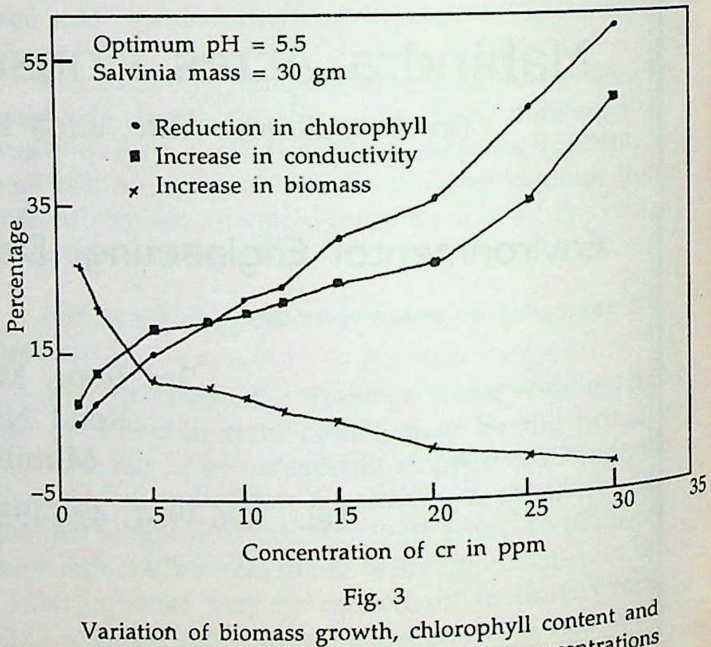

Fig. 3
Variation of biomass growth, chlorophyll content and conductivity under different chromium concentrations

course will not affect the well yield because the seepage water from Dam will serve the purpose comfortably.

REPLY *by Shri V. Satyamurthy, co-author*

While appreciating the core point of the technical paper that the sub-surface phenomenon is responsible for the high fluoride level in the surface water, Mr. P. Mariappan has added in his comment that the fertilizer and pesticide residuals (containing about 1 to 2% fluoride) out of modern wet cultivation practices on the banks of the Thenpennaiyar may also be responsible for the high fluoride level in surface water at the intake point of the Kaveripattinam Water Supplies.

Based on the survey carried out on the seven kilometre stretch from Krishnagiri dam upto and beyond Kaveripattinam Water Supply intake point and subsequent collection, it may be pointed out that there is no appreciable farm drainage from the agricultural fields nearby either on the upstream side or the downstream side of the river.

If such a phenomenon as advocated by Mr. P. Mariappan is prevalent there should be abnormality in fluoride concentration both on the upstream and downstream sides which is not existing.

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2 Pilot-plant studies

Gary S. Logsdon, Shawn La Bonde,
Donald Curiey and Roger Kohne

Pilot-plant studies are often considered appropriate or necessary for effective planning, design, and operation of water treatment facilities. By carefully planning pilot-plant investigations before they are undertaken and by diligently conducting the study, water utility staff and engineers can maximize the return on the resources invested in pilot-plant programs. This article contains ideas and concepts on pilot-plant testing that have been developed through two decades of work with pilot plants.

(Ref. : Journal of A.W.W.A., March 1996, Page-56)

Discussion by P. Mariappan on the Paper*

'Fluoride contribution to surface water from subsurface strata — A case study

by **Dr. Ramalingeiswara Rao** and **others**, published in January-March 1996 issue of the Journal of IWWA on pages 27 to 30.

I wish to express my following views based on Geological, Topographical and Land use pattern of study area.

Geological formation in the study area is generally of hard rock and principal rock types prevailing are igneous and metamorphic granite and gneisses. Igneous and metamorphic rocks contain Fluoride as a component of Amphiboles and other minerals. Shallow depth of top soil is encountered. As rightly pointed out by the authors, the substrata on which the Infiltration well is rest, may be one of the reasons for high Fluoride.

The study area forms a part of Krishnagiri Dam ayacut and two crops are cultivated in a year Paddy being the main crop. In modern cultivation practice, Fertilizer is applied to enrich the nutrients of soil for healthy crop and high yield coupled with application of pesticides for pest control. Such fertilizers and pesticides do contain Fluoride component. Phosphatic fertilizer such as Diammonium phosphate (DAP) contains roughly 1 to 3% of fluoride in them.

So, the application of chemical fertilisers and pesticides will increase the fluoride content of soil and the water which drains from the field accordingly. As the water infiltrates and seeps, the fluoride will subsequently be carried down along its travel path. Here the chance of deep percolation is very remote except in fracture zones. The water which infiltrates the earth crust must necessarily seep through soil pores and along the rock interface according to the terrain slope. The terrain naturally slopes towards the river in the study area. The area commanded in between by the Right and Left canal of Krishnagiri Reservoir Project and western side of NH7, do drain into the river portion chosen for the study by the authors. Water which thus seeps appears as spring at river surface causing surface flow in the river and also flows into the sand media as subsurface water making the sand media as a shallow aquifer from which water is extracted through the Infiltration wells for the water supply. Hence same may be the other reason for rich fluoride content.

Sand depth in the river course increases from very few centimetres, even rock is seen at ground level immediately downstream side of Dam, to fairly 6 to 7 metres in between the Dam and Kaveripattinam head works respectively. Similarly at Kaveripattinam also the rock is seen as outcrops. In between Sundekuppam and Kaveripattinam, sufficient sand depth is available for sinking infiltration wells and hence the sources for Krishnagiri and Kaveripattinam have been chosen in that stretch. This natural phenomenon will arrest the subsurface flow downstream side from the well infiltration site making seepage water stagnate and cause deposition of fluoride. This may be the reason for high fluoride in soil at site 20 metre west to infiltration well and less in downstream side.

Alternatively, pumping in infiltration well will make the streamlines (i.e. flow lines) converge towards well from all directions. Here, the infiltration well will be acting as a Sink resulting in more fluoride movement towards infiltration well by either advection or dispersion.

Following suggestion is made to tide over this problem :

As said earlier, the drainage water entering into the sand bed in river course may be the primary factor. It has to be necessarily stopped reaching into the river course. There is already a canal running parallel to the river course on its bank. Field drains may suitable by connected with this canal and the drainage water may be carried off to downstream. This existing canal may be deepened if necessary. Stopping drainage water entering into the river meters determine the required pretreatment and the array staging of the reverse osmosis installation. The design of the pretreatment of the raw water is of the utmost importance, because an adequate pretreatment prevents fouling and distortion of the membrane. Checking the proper functioning of a reverse osmosis installation requires continuous monitoring and registering of the major parameters for operation. The data obtained will help in making calculations that give a good indication of the fouling of the membranes and the required cleaning frequency.

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* Assistant Engineer, TWAD board, Sivagangai-623560.

The quality of the raw water and the design of the reverse osmosis installation determine the method of pretreatment. Requirements for the influent are :

Fe < 0.1 mg/l
Mn < 0.05 mg/l
Cl < 0.1 mg/l
prefiltration

Protecting the membranes against the deposit of nondissolvable salts (like $CaCO_3$), requires adding an acid to the water, in combination with a phosphate if necessary. Instead of this treatment, it is possible to use a demineralization installation placed before the membrane filtration.

Reverse osmosis applications include the treatment of potable water, cooling water, boiler water, production water, ultra pure water and waste water. Major customers for reverse osmosis installations are the suppliers of potable water, hotels, hospitals and clinics, laboratories and various industrial companies whose products include cosmetics, pharmaceuticals, glass, chemicals, petrochemicals, food and beverages.

The standard installations for reverse osmosis have a salt removal of minimally 97 percent at an efficiency of approximately 75 percent (for potable water supply).

A large variety of sizes and capacities are available for reverse osmosis installations varying from 40 l/h for the smallest to 40,000 l/h for the largest standard installation. The operating pressure bar varies from 14 to 16 and the electric power ranges from 0.55 kW for a small model to 37 kW for a large installation that includes 40 reverse osmosis modules. The dimensions of the plants vary from 650 x 350 x 1,000 mm (for length, width and height) to 5,000 x 1,000 x 1,900 mm.

2 A delicate balance

When drinking water purveyors first used chlorine to combat waterborne illness, little could they have guessed they were creating another problem — disinfection by products (DBPs). Although DBPs occur in most treated surface supplies, their nature and concentration vary, depending on the organic carbon content of the raw water and the treatment processes used.

In the hope of reducing DBP formation, some utilities have switched to ozone as their primary disinfectant. However it produces undesirable byproducts of its own. Ozone, for example, reacts with bromide contained in the raw water to form bromate ion — believed to be carcinogenic. Ozonation DBPs investigated are reduced by a combination of ozonation and biotreatment. Controlling waterborne diseases and DBPs involves a delicate balancing act. If vigilance — and disinfection — fail, epidemics can occur anytime, anyplace, because these diseases are not eradicated but only kept at bay. Like the DBP dilemma, the ghostly image of cholera lingers with us as well.

(Ref. : Journal of A.W.W.A. — October 1995 page 45)

SYNOPSES OF PAPERS PUBLISHED IN OTHER TECHNICAL JOURNALS

1 Water quality and disinfection kinetics

Charles N. Haas, Josh Jotte, Uma Anmanganla, Josheph G. Jackengelo and Mark Heath

The contact-time tables of the US environmental protection agency are based on survival data obtained in buffered demand free water. However, disinfection data from experiments conducted at Drexel University showed that the choice of source water influences the degree of inactivation. Sophisticated disinfection kinetic models and statistical tests are used to analyze the sources of these discrepancies. This article demonstrates that the quality of a particular source water is a significant factor in predicting disinfection effectiveness.

(Ref. : Journal of A.W.W.A., March 1996, Page-95)

Short Communications

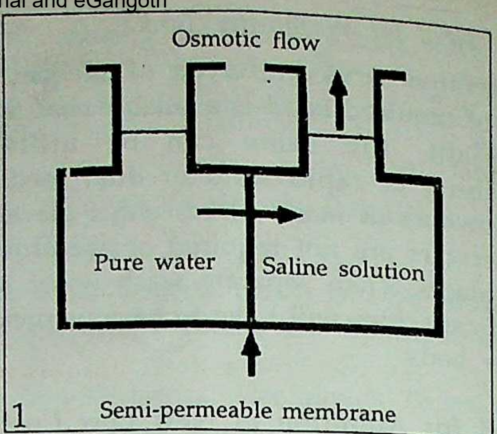
1

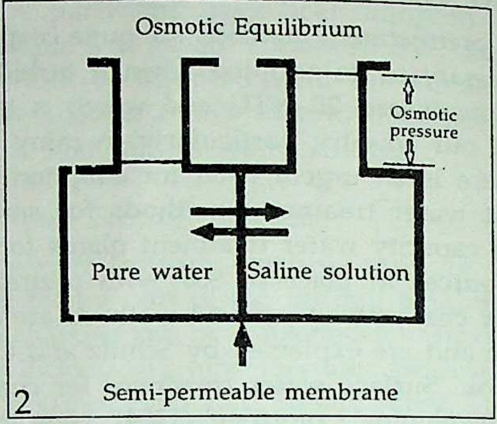
Reverse osmosis installations treat water for many uses

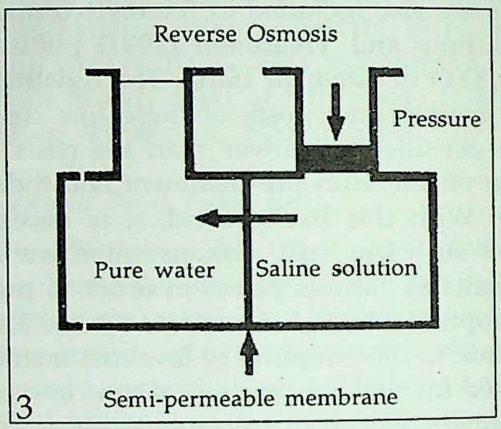
The reverse osmosis technique removes dissolved salts and low molecular polar and nonpolar compounds from the water. Potable and process water production and wastewater purification use this technique. Reverse osmosis is also gaining popularity in the food and beverage industry. Osmosis is the natural phenomenon that pure water will flow to the highest salt concentration through a semipermeable membrane. As soon as the molecular collision pressure is equal on both sides of the membrane, the net water flow will cease. The corresponding difference in liquid head is called osmotic pressure. By applying an artificial counter pressure, which is higher than the osmotic pressure, one can reverse the direction of flow of the water. This phenomenon is reverse osmosis.

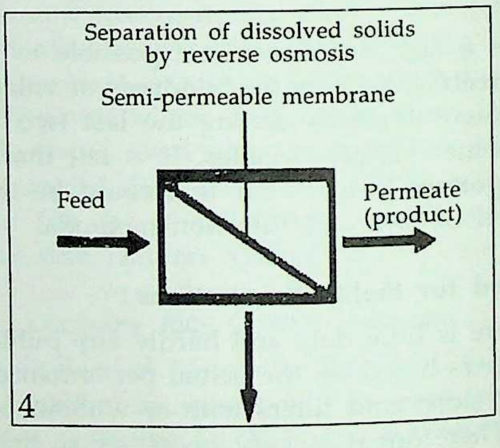
The required level of counterpressure greatly depends on the salt content of the water, as the salt content determines the osmotic pressure to be overcome. Brackish water has an osmotic pressure of approximately three bar. The osmotic pressure of sea water is about 20 bar. In reverse osmosis installations, a closed pressure vessel contains the membrane and the feed flow is the water to be purified. The water passes through the membrane, which rejects its dissolved and nondissolved substances.

The separation characteristic of the applied membrane determines the extent of substance removal. The substances for removal (ions, molecules, colloidal and floating matter) will concentrate and continuously discharge in the so-called concentrate or brine stream. By this increase of concentration and dewatering the feed flow, the osmotic pressure in the brine will grow considerably. For this reason, reverse osmosis installations for sea water operate at pressure levels from 60 to 70 bar. Brackish water installations are usually at 15 to 30 bar.


Osmotic flow
Pure water
Saline solution
Semi-permeable membrane
1


Osmotic Equilibrium
Osmotic pressure
Pure water
Saline solution
Semi-permeable membrane
2


Reverse Osmosis
Pressure
Pure water
Saline solution
Semi-permeable membrane
3


Separation of dissolved solids by reverse osmosis
Semi-permeable membrane
Feed
Permeate (product)
4

The design of a reverse osmosis installation requires considerable expertise. A thorough understanding of water chemistry and bacteriology, as well as special knowledge concerning deposit formation and bacteriological fouling on membranes is mandatory. Among the major design parameters in the design of the installation are turbidity, the presence of gases, temperature, pH, free chlorine content, salt content and the membrane filtration index (SDI/MFI). These process technological para-

3.5 *Need for Washwater Tank :*

If elevated service reservoir of adequate capacity and of required head is available near the treatment plant, the same can be utilised for backwashing of rapid sand or dual media filter beds. However at many places either elevated service reservoirs are not required or are provided at distant places. Then separate wash water tanks of required capacities will have to be constructed near the filter beds.

4. Need for Adoption of New Low Cost Water Treatment Methods :

The pretreatment methods are quite costly. They are necessary to be adopted when if turbidities in raw water exceed 20 NTU and which is the situation in our country particularly in rainy season. Thus there is an urgent need for adoption of new low cost water treatment methods for small and medium capacity water treatment plants for turbid water sources in place of SSF with pretreatment. Such low cost water treatment methods are already available and are explained by Schulz and Okun in their book 'Surface water treatment for communities in developing Countries' (1984). New low cost methods are also included in the revised manual on water supply and Treatment (1991) published by CPH & EEO of Govt. of India. The construction as well as maintenance costs of these low cost methods are considerably lower than the costs of construction of SSF with pre-treatment and their maintenance. With this background, it is necessary to construct such low cost demonstration water treatment plants at various places in order to propagate their adoption for turbid water sources. The large saving due to the adoption of low cost methods can be utilised for the construction of new low cost water treatment plants in villages.

It is a fact that it was not possible to provide water treatment plants for hundreds of villages and small towns in India during the last two international water supply decades. It is felt that one of the important reasons for this could be the non-adoption of low cost filtration methods.

5. Need for Field Observations :

There is little data and hardly any publications and papers based on the actual performance of the existing slow sand filters with or without pretreatment. Therefore it is very necessary to bring forward the actual plant scale performance results of the existing old and new slow sand filtration plants which are under operation for a minimum period of three to five years. There is also a need for detailed discussion on such actual plant performance data and also on the various points raised in this paper. Such a discussion will certainly help to bring out appropriate low cost water treatment methods for adoption in the villages and small towns in India and in other developing countries in the near future.

6. Conclusions :

The aim of the paper is to bring out simple low cost methods for modification of the existing slow sand filtration plants with or without pretreatment methods, which do not give satisfactory performance due to various reasons as discussed in this paper. These low cost methods will be useful for improvement as well as for augmentation purpose of the existing SSF plants where needed.

There is an urgent need for the adoption of new low cost water treatment methods for hundreds of villages and small towns for turbid water sources (> 20 NTU) so as to provide potable drinking water supply where it is not yet available. Their cost of construction and maintenance will be considerably lower than cost for the SSF plants. Further, these can be constructed within a short period.

There is a great need for actual field observations on the existing SSF Plants and detailed discussion on their performance and various points raised in this paper.

References :

1. Kardile, J. N., 'Observations on some semi-rapid and slow sand filters in Maharashtra State,' JIWWA, Vol. 2, No. 4, October, 1970.
2. Maharashtra Engineering Research Institute, Nashik, 'Study of the actual performances of some slow sand filters in Maharashtra State', A special report by Env. Eng. Res. Division, MERI, Nashik (1984).
3. WHO International Reference Centre for Community Water Supply, 'Slow Sand Filtration for Community Water Supply in Developing Countries'. A Design and Construction Manual, Technical Paper No. 11, December, 1978.
4. WHO International Reference Centre for Community Water Supply and Sanitation, 'Slow Sand Filtration for Community Water Supply: Planning, Design, Construction, Operation and Maintenance', Technical Paper No. 24, June, 1987.
5. Ministry of Urban Development, New Delhi, CPH & EEO, 'Manual on Water supply and Treatment', (Third Edition) March, 1991.
6. Schulz, C. R. and Okun, D. B., 'Surface Water treatment for communities in developing countries', John Wiley & Sons, New York, 1984.
7. Kardile, J. N., 'Simple Methods in Water Purification', India, 1987.

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2.3.3 *Dual Media Filter Beds :*

As the headloss available between the TWL of slow sand filters and pure water sump was about 1.0 metre, dual media filter beds were adopted so as to operate at lower filtration rate and within lower headloss limit of 1.70 m. TWL in pure water sump is lowered by one metre to get this headloss. Five dual media filter beds are provided for an average filtration rate of 5000 lph/sqm. The size of each dual media filter bed is 3.65 m x 2.3 m with surface area of 8.4 sqm. Thus during washing of one filter bed, the rate of filtration can be increased to 6250 lph/sqm, which is easily possible with dual media filter beds. The filter media consists of 30 cm of crushed coconut shell coarse media of size 1.0 mm to 2.0 mm over 40 cm depth of fine sand of E.S. of 0.5 mm and uniformity coefficient of about 1.5. Below sand media, supporting graded gravel of 50 cm depth are provided over under drainage system. The under drainage system consists of 30 cm dia M.S. manifold and side perforated laterals of 50 mm dia rigid PVC pipes. Suitable inlet channel, C.I. piping and valves are provided by the side of the converted settling tank. Filtered water outlet and wash water inlet piping and valves are provided on the outlet side. There is only one outlet control chamber with central weir of 2.0 m x 1.0 m size with a master control valve to work as declining rate control flow arrangement. The outlet pipe of 400 mm from the control chamber is connected to the existing small sump below the chlorine dosing room. Chlorinated water is further taken to the existing pure water sump from the existing pipe line. See fig. 1 on page 178 for modifications in converted settling tank and of dual media filter beds.

2.3.4 *Wash Water Tank :*

A wash water tank of one lakh lit capacity was constructed near the dual media filter beds to give effective hard wash through 250 mm dia piping and sluice valves. One pipe line of 150 mm dia is connected to the existing pumps to fill the wash water tank. Water from this new wash water tank will also be distributed to three villages situated at higher level near the plant. Washed water from the RCC gutters from the filter beds is taken out from the inlet side by suitable arrangements to simplify the outlet side pipe gallery. Washed water disposal drain is also provided at the inlet side so as to transport the waste water into the existing drain line.

2.3.5 *Other Modifications :*

Some minor modifications for raising inlet raw water weir, proper alum solution and dosing arrangements, raising the masonry side walls of second settling tank, providing by-pass channel to filters for cleaning second settling tank etc. are also carried out.

3. Other Options in the Modification Techniques :

Some other options which can be adopted for modification of SSF Plants are discussed below.

3.1 *Non-Mechanical Flocculation Technique :*

In the Malmatha SSF plant, perforated half cut PVC pipe partitions have been adopted as it is found simple and cheap. However, PVC angle floc modules can be adopted with the advantage of better flocculation action with lower detention capacity for high turbid water sources.

3.2 *Tube Settling Technique :*

If hopper bottom settling tank is already adopted, then a part of the settling tank after flocculation chamber can be converted into tube settling tank by introducing tube modules fabricated from 50 mm x 50 mm rigid PVC square tubes. This technique will be more useful for turbid water sources, where the existing plant capacity is to be augmented by 50% to 100%. This technique is already adopted for modification of SSF plants at Mangaon and Dindori Villages in Maharashtra.

3.3 *Rapid Sand Filter Beds :*

In the Malmatha SSF Plant, dual media filter beds have been adopted which have got the advantage of operation at lower headloss for 0.6 to 1.0 m which is normally provided between the TWL in SSF beds and the outlet weir level in the control chamber. Additional advantages of lower construction cost and saving in the wash water consumption can also be available by adoption of dual media filter beds, particularly for bigger plants. For small SSF plants where adequate headloss facility is available, rapid sand filter beds of required sizes can be adopted. Rapid sand filter beds are already adopted for the modification of SSF plants at Mangaon and Dindori Villages.

3.4 *Declining Rate Control Technique :*

As provided at Malmatha SSF Plant, the declining rate control technique will be very useful for SSF plants operating for 24 hours and having more than two filter beds. Additional advantages of simplicity in operation and better filtrate quality are also available.

TABLE 2

Hydraulic Design for the Modifications proposed for Improvements in the Existing slow sand filter Plant at Malmatha.

Designed flow	5.0 mld
Flow per hour	2,08,000 Litres
	Say 2,10,000 Litres.

1. Modifications in Existing Settling Tanks:
   Size: Two units of 20.0m x 6.5m x 2.5m

Flocculation zone: 1/3 length of existing units

$$\therefore \text{ Detention capacity : } \frac{2 \times 6.5 \times 20 \times 2.5}{210} \times 1/3$$

$$= \frac{208.12}{210} \text{ Say 1 Hour}$$

Settling tank zone: 2/3 of existing capacity of three hours = Thus Two Hours.

2. Conversion of one SSF Bed into settling Tank:
   Size of SSF Bed: 22.0m x 13.0 x 2.5m

$$\therefore \text{ Detention period : } = \frac{22 \times 13 \times 2.5}{210} \text{ 3.40 Hrs.}$$

Thus, total detention
period = 2.0 + 3.4 = 5.40 Hours.

3. Conversion of one SSF Bed into Dual media filter Beds.
   Provide five filter
   beds of size = 3.65m x 2.3m

∴ Surface Area of each Bed = 8.4 sqm.

$$\therefore \text{ Rate through Dual Media FilterBeds : } = \frac{2,10,000}{8.4 \times 5} \text{ 5,000 lph/sqm.}$$

$$\therefore \text{ Rate of filtration during washing of one filter bed } = \frac{2,10,000}{8.4 \times 4}$$

$$= \text{6.250 lph/sqm.}$$

This higher rate is well within the limits for a dual media filter with longer filter run, and less consumption of water for back washing as compared to rapid sand filter beds.

These modifications were completed at a cost of Rs.14 lakh in just one year by December 1991 by calling tenders.

2.3.1 *Modifications in the Existing Settling Tank:*

The size of the existing two units of settling tank is 20.0 m x 13.0 m x 2.5 m upto top water level (TWL) from the top of bottom hoppers. There are six hoppers at the bottom of each unit for removal of sludge under hydrostatic pressure. During the modification work 1/3 portion of the settling tank was converted into non-mechanical flocculation zone by providing six numbers of perforated partitions in each unit. One RCC partition wall was provided at the end of flocculation zone. For proper distribution and uniform flow through the flocculation tanks, six 150 mm dia PVC pipes were provided with side perforations at the inlet and outlet ends. The flocculated water is introduced in the next settling zone at about 2/3 depth from the TWL. The perforated partitions were fabricated by fixing half-cut 63 mm dia rigid PVC pipes at 12 cm centre to centre spacings on to M.S. angle frames. The detention period in flocculation zone is about one hour and there is uniform horizontal flow in the tank due to this arrangement, for achieving proper flocculation. The remaining portion of the settling tank units has two hours detention period. The level of the outlet weirs of the existing settling tank units was raised by 20.0 cm to get the required head of water in the second settling tank and filter beds.

2.3.2 *Conversion of One Filter Bed into Settling Tank:*

In order to provide adequate settling capacity, one slow sand filter bed was converted into second settling tank by suitable inlet and outlet modifications. The bottom was kept as it was after removing all the inside material. The sludge from this tank will be removed manually once or twice in a year as found necessary. Thus the detention capacity of this settling tank of 3.40 hours is added to the detention of existing settling tank of 2.0 hours, and the overall detention period is about 5.40 hours. The inlet and outlet channels are provided with their top levels raised suitably. At the inlet end 12 Nos. 150 mm dia PVC Pipes are provided from the inlet channel to introduce the water at about 2/3 depth below the TWL of the tank. At the outlet end a collection channel is provided with 80 mm dia pipe outlets — 50 numbers — to keep the TWL at desired raised level.

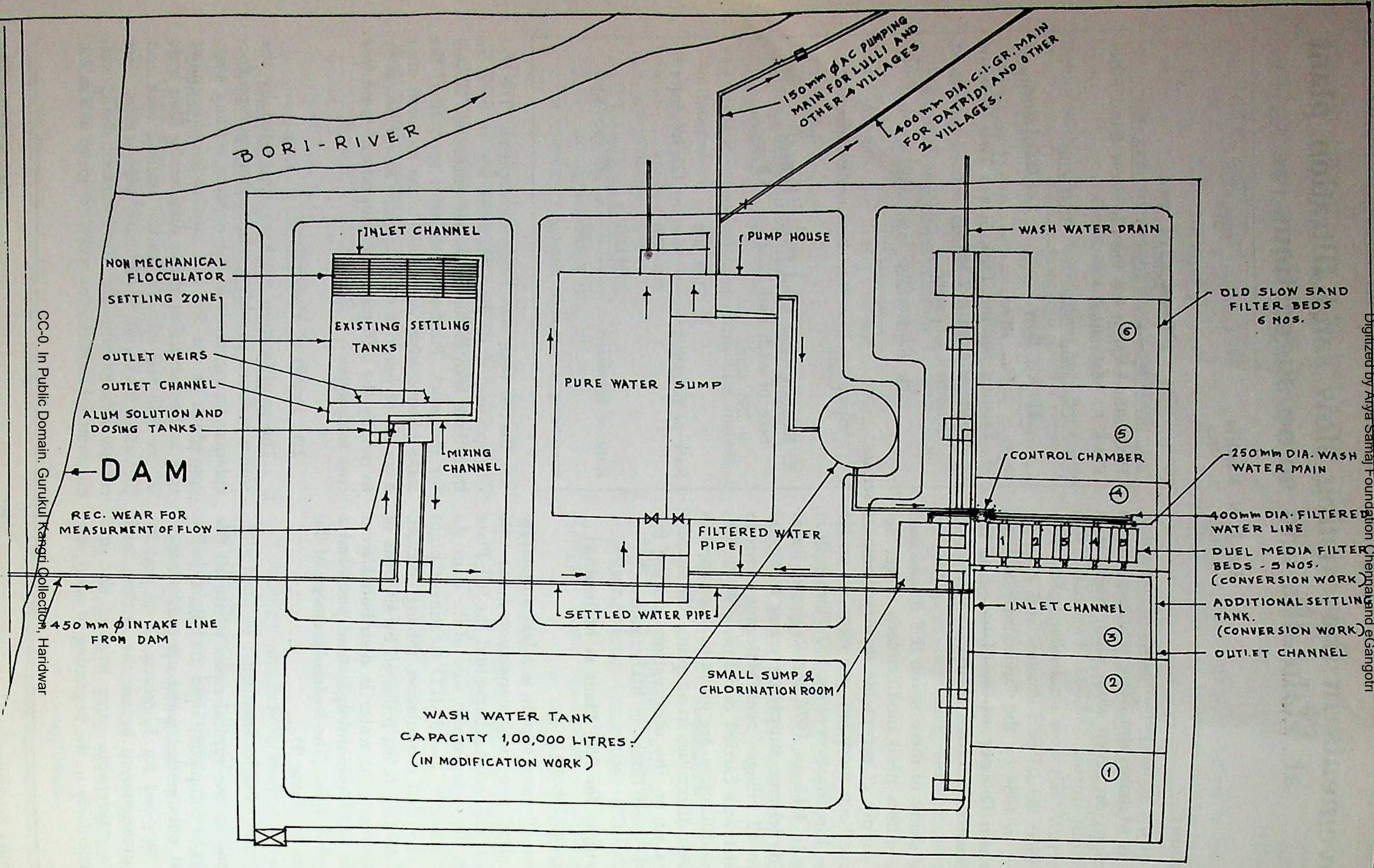
BORI-RIVER
150mm ϕAC PUMPING MAIN FOR LULLI AND OTHER 4 VILLAGES
400mm DIA. C.I. GR. MAIN FOR DATRIDI AND OTHER 2 VILLAGES.
INLET CHANNEL
PUMP HOUSE
WASH WATER DRAIN
NON MECHANICAL FLOCCULATOR
SETTLING ZONE
EXISTING SETTLING TANKS
OUTLET WEIRS
OUTLET CHANNEL
ALUM SOLUTION AND DOSING TANKS
MIXING CHANNEL
DAM
REC. WEAR FOR MEASURMENT OF FLOW
450mm ϕ INTAKE LINE FROM DAM
PURE WATER SUMP
FILTERED WATER PIPE
SETTLED WATER PIPE
OLD SLOW SAND FILTER BEDS 6 NOS.
⑥
⑤
④
③
②
①
CONTROL CHAMBER
250mm DIA. WASH WATER MAIN
400mm DIA. FILTERED WATER LINE
1
2
3
4
5
DUEL MEDIA FILTER BEDS - 5 NOS. (CONVERSION WORK)
INLET CHANNEL
ADDITIONAL SETTLING TANK. (CONVERSION WORK)
OUTLET CHANNEL
SMALL SUMP & CHLORINATION ROOM
WASH WATER TANK CAPACITY 1,00,000 LITRES. (IN MODIFICATION WORK)

Fig. 1
Layout plan of slow sand filter plant at Malmatha showing modifications

Improvements in the existing slow sand filtration plant at Malmatha and some suggestions

Dr. J. N. Kardile

1. Introduction :

A study of the actual performance of some slow sand filters in Maharashtra State was carried out and observations on seven slow sand filter plants were carried out during 1982-83. Two old (1900) and five new (1970-80) slow sand filters (SSF) were studied for their actual performance and a report was prepared in 1984 by the Environmental Engineering Research Division of the Maharashtra Engineering Research Institute, Nashik.

From the study of these seven SSF it was seen that all these filters need modifications to get desired water supply of acceptable quality. Some of these SSF have been modified and some are under modifications. Modification of the SSF Plant built at a cost of Rs.16 lakh in 1976 for Regional Rural Water Supply Scheme supplying water to 80,000 population in 42 villages near Malegaon town in Nashik District was carried out during 90-91. Details of the modifications are given in this paper. In addition to this, difficulties in adopting SSF are also discussed, based on the observations during the study of slow sand filters in Maharashtra.

2. Modifications for SSF Plant at Malmatha :

2.1 *Original Scheme :*

The source of water supply is a lake formed by an earthen dam specially constructed for this scheme. This is a gravity scheme and the SSF Plant is situated on the downstream side of the dam. As per original scheme, the 5 MLD treatment plant consisted of chemical coagulation, mixing channel, two units of settling tanks followed by six beds of SSF. After disinfection, water is distributed from ground service reservoir through stand posts and a few house connections. (The hydraulic design of the plant is given in Table 1).

2.2 *Need for Modifications :*

This is one of the typical cases where all the SSF beds clogged completely upto the bottom in the first year and only settled water after chlorination was getting supplied for 10 years. There was no flocculation arrangement before the settling tank and due to considerable carry over of floc and turbidity, particularly in the beginning of rainy season, the SSF beds were clogged completely. The cost of regrading of all the filter beds was to be more than three lakh of rupees as per quotations invited for the work. Further, even after regrading, the same phenomenon was likely to be repeated after a couple of years. It was therefore found necessary to modify the SSF plant by adoption of some low cost techniques.

TABLE 1

Hydraulic Design for the old Slow Sand Filter Plant At Malmatha.

Designed flow	5.0 mld
Hourly flow	2,08,000 Litres.

1. Existing Settling Tank Sizes : Two Units of 20.0m x 6.5m x 2.5m
Detention Capacity

$$= \frac{20 \times 6.5 \times 2.5}{208}$$

= 3 Hours.

2. Existing slow sand filters : 6 Beds :
Size of each bed 22.0m x 13.0 m
= 286 sqm.

$$\text{Rate of filtration} = \frac{2,08,000}{6 \times 286} = 121 \text{ lph/sqm}$$

$$\text{Rate of filtration} = \frac{2,08,000}{5 \times 286} = 145 \text{ lph/sqm}$$

(considering one bed under cleaning)

2.3 *Details of Modifications :*

The modification work as suggested by the author included providing non-mechanical type flocculation arrangement in the existing settling tank, conversion of one SSF bed into additional settling tank and construction of five dual media filter beds in one SSF bed adjacent to the settling tank and providing backwash water tank, pipe gallery, rate control arrangements etc. The hydraulic design calculations for modification work are given in Table 2.

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(i) A special repairs programme be chalked out for mending defective schemes. Evaluation of such schemes be first made for considering the renovations or the rehabilitation measures.

(ii) In order to avoid frequent tripping of electromotor pumping sets due to low electric supply/voltage, the electric supply should be strengthened by providing additional transformers, sub-stations with high tension electric transmission lines, etc. An amount of Rs.300 Million, be given to the state electricity board for this purpose.

(iii) The society of ex-service men shall be given preference for allotting the work of O & M.

(iv) For effective O & M, necessary training shall be imparted to atleast 2 persons from every Gram-Panchayat.

(v) One unit/division will be created in each Zilla-Parishad(ZP) for looking after the problems of O & M and simultaneously the subdivision shall be operated in each of the Taluka places.

(vi) The existing water supply tariff shall be updated to make the schemes sustainable.

3.2.1 *Provision of Fund for Operation and Maintenance (O & M):*

The ZPs should create village water supply O & M fund from their own cess, reserving an amount of 20% of the revenue. At the same time the state and central Governments shall give funds to the extent of 10% of the budget provision.

Grant-in-aid to the extent of 50% of the energy charges be given to the Gram Panchayats (GP) for their individual schemes and to the ZP for regional rural schemes. Also 50% subsidy in the cost of bleaching powder be given to the GP/ZP.

3.3 *Setting Up of a New Administration Authority:*

There are number of agencies such as MWSSB, GSDA and the ZP involved in rural water supply in the state. The departments of Irrigation and Jalsandharan are also involved in it. An apex authority to co-ordinate all these agencies and departments shall be created in the Mantralaya of GOM. The part of work with ministry of Rural and Urban departments in Mantralaya shall also be attached to this new ministry (Such a ministry has been now formed).

The Government of Maharashtra has also declared in this white paper the following priorities for water usages: (i) for drinking, (ii) for irrigation and (iii) for industry. A water authority under the chairmanship of the Chief Minister has been now established. The responsibilities of this authority shall be: (a) to study and prepare a master plan for the availability of surface and ground water sources in the state and utilize them optimally, (b) to frame a policy to consider measures to be adopted for augmenting the water sources, (c) to study the latest developments in the management techniques in the country and abroad and using them for the welfare of the state.

3.4 *Funds required:*

The state Government will pursue the Central Government for allotting maximum funds required for the programme of water supply and sanitation in the state. Funds shall also be raised by way of loans from institutions like LIC etc. A consultant shall be appointed to study and prepare the schemes for securing maximum funds even from the external funding agencies such as World Bank, ODA, OECF etc. In addition to these steps, privatization in building, operating, leasing and transferring the schemes shall be considered.

4. Conclusions:

The white paper considers the entire gamut of the steps required for proper utilization of water in the state. It also presents a rational approach for strengthening the water sources and forms guidelines for effective O & M of the projects. The state shall step into the 21th century with rapid industrialization and growing water demands and the white paper will help enhance the state's reputation in managing the water crisis even in future.

5. Acknowledgement:

The author wishes to express his thanks to Mr. Ranganathan, Principal Secretary, Department of Water Supply and Sanitation ministry (GOM) and Rajendra M. Sagane, Member Secretary, MWSSB, respectively for their encouragement and valuable suggestions in the preparation of this paper. He is also thankful to Dr. S. V. Dahasahasra, Superintending Engineer, ENE circle, Pune, Mr. S. G. Parkhi, E.E., Pune and Mr. A. S. Ayachit, Asstt. S.E., Pune — all of MWSSB — for assisting him in writing the text of this paper.

Reference:

White Paper, Published by GOM, 1995.

important decisions to be taken due to adoption of this policy would be :

(a) **Population projections** : The population projection for rural water supply scheme should be done alike the one adopted in urban project. In the present practice (prior to adoption of white paper), the population of the immediate stage (after 15 years) is computed by considering only 1.08% increase in population per year. This practice shall now cease and the average of the incremental increase and the geometric growth method will be adopted for the purpose.

(b) Rural water supply schemes are presently designed for a period of 15 years only. But due to rapid population growth, the carrying capacity of supply pipe lines becomes inadequate resulting in shortage of supply within 5 to 8 years of completion of the schemes. All the major components of the schemes are to be now designed for 30 years except for the pumping machinery which will be designed for 15 years.

(c) The present water supply norm is 40 litres per capita per day (LPCD). Due to increasing standard of living in the rural sector also, higher quantities of water are being demanded. The norm of supply has to be raised to 55 LPCD, which includes supply at the rate of 70 LPCD for 30% population through individual house connections, at 40 LPCD for rest of the population through public stand posts and at 6 LPCD for cattle population.

(d) While planning urban water supply schemes, the water demand of en-route villages was not being included in the existing practice; but now it will have to be considered. In addition to this, the responsibility of providing water to the peripheral villages on the outskirts of the urban centres within 5 kms radius will now be saddled with the respective municipality or the corporation.

3.1.2 *Measures to Utilize All the Sources :*

In order to utilize limited ground water as well as surface sources, the following decisions have been taken :

(i) Priority will be given to the piped water supply from Reservoirs over a canal or the simple river intakes.

(ii) All the irrigation projects will have to be now designed taking into consideration the demand for domestic water supply (as well) of the command area.

(iii) Strengthening of the source by simple measures for water conservation.

(iv) A slogan, *'Gaon Tethe Tale'* (small water lakes in every village), is accepted for implementation.

(v) Permission, for inclusion of the 'Bridge-cum-bandhara', (impounding the water by way of weir with gates constructed across the piers of the bridge), will be considered wherever the sites are plausible.

3.1.3 *Measures to obtain and keep up the Quality of water :*

For supplying potable water to the communities, pollution, accrued right from the source shall have to be prevented and for this the following decisions are taken.

(i) The agriculture department will devise and enforce methods for preventing excessive use of fertilizers, which finally reach sources of water, polluting them.

(ii) Excessive withdrawal of the ground water near sea shore shall be prevented by suitable enactment. This will help in avoiding the intrusion of sea water into the subsurface water and degrading its quality.

(iii) Areas with excessive chlorides, fluorides and iron etc. (in sources of water) will be studied in depth by the Maharashtra Water Supply and Sewerage Board (MWSSB) and an action plan shall be prepared to counter such problems.

(iv) Water supply schemes shall be tackled integrally along with the sanitation programmes which includes low cost sanitation, construction of surface drains, health education etc.

(v) 50% subsidy will be given for purchase of bleaching powder to the local bodies and small municipalities for disinfection of their water supplies.

3.2 *Implementing vigorous and effective Operation & Maintenance (O & M) :*

Since large amounts are being spent in the construction of water supply schemes, it is expected that such schemes remain efficient in rendering the desired service to the rural mass. So also such schemes should be financially self sufficient and hence the water tariffs should be reviewed and modified from time to time. Following decisions in respect of effective O & M have been taken to achieve these objectives :

Sustainability of drinking water supply schemes in rural areas of Maharashtra state

S. V. Shelkikar*

Synopsis :

Safe and adequate drinking water is a prime requirement of human society. Government of India(GOI) and Government of Maharashtra (GOM) have earmarked a substantial amount of funds to implement water supply programme both in rural as well as urban sectors since independence. WHO had declared 1981-1991 as the international water decade. In spite of vigorous implementation of programmes, the goal of supplying safe drinking water to the community is not achieved fully. There is a huge demand of water supply on one side, at the same time on another side, society has become aware of the quality and standard of the service. GOM has, therefore, issued a white paper (White Paper, 1995) on this vital issue to achieve the sustainable water supply programme. This paper aims at highlighting the provisions of the white paper pertaining to rural areas in particular.

1. Introduction :

Maharashtra, the third largest state in India with 30 districts and 43,020 villages and 51,162 small habitations (Wadis), has 61% rural population. Present population of Maharashtra is 78.93 Million, out of which rural population is 48.39 Million (61%). The population has increased two fold during last 30 years. During 6th five year plan, total 15,883 villages were covered in the state out of 17,112 problem villages. During 7th five year plan, total 18,257 villages have been covered out of 23,306 problem villages as per survey of 1980. Till today total expenditure incurred on this programme is Rs.20,000 Million. Despite such a huge outlay, the recent survey conducted under Rajiv Gandhi National Drinking Water Mission (RGNDWM) in 1991-93, there are 16,790 villages and 18,426 habitations which are yet to be fully tackled. Because of elevation of the standard of living in rural population too, the disparity of per capita consumption of 40 litres and 125 litres in rural and urban areas respectively have caused agony, especially in rural community. Therefore, a demand of supplying water at the rate of atleast 55 to 70 litres per capita has come to the surface. The rural community also demanded to reserve a small share of water to be included for their cattle. Considering these difficulties and the hardships faced by the people (GOM) has issued a white paper to ameliorate the situation.

This paper aims at presenting the salient features of the white paper which contains a rational approach to solve the problem of drinking water in the state.

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2. The problems of rural water supply :

The rural water supply schemes are being executed all over the state. The state has taken a major leap in implementing the rural water supply programme. The state has a peculiar geography of the Deccan Basalt track, because of which the surface run-off is maximum and the underground storage is meagre. Therefore, the problem is more aggravated in comparison with other states. The other main reasons as stipulated in the white paper for inadequate water supply are : (i) population explosion, (ii) inordinate exploitation of the underground water compared to the recharging of the ground water, (iii) lack of proper planning in implementation of rural water supply programme, (iv) deficiencies in design of rural water supply schemes, (v) dwindling quality control in execution of the schemes, (vi) poor operation and maintenance (O & M) of the completed schemes by the local authorities, (vii) higher expectations of the common people regarding water supply, (viii) increased pollution of the existing sources, (ix) missing co-ordination in interdisciplinary authorities and (ix) paucity of funds. The complexity and intermingling of these aspects deteriorate the situation.

3. The solution contemplated in white paper :

The white paper comprehends all the above listed problems and suggests the steps to be taken to improve the situation in the state. The GOM has, therefore, framed some policies and adopted important decisions for proper planning, implementation and operation and maintenance of the rural water supply programme.

3.1 *Adopted Policies and Decisions :*

The main policies/decisions are enumerated in the following paras.

3.1.1 *Removing Disparity of the Norms :*

The white paper suggests to remove the disparity in norms of water supply of rural and urban sectors. It further proposes to narrow the gap between the norms of planning and execution too. The

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BOOK REVIEW

Title : क्लोरीनीकरण एवं क्लोरीनीयोंका उपयोग
Authors : Dr. D. D. Ozha & Dr. T. A. Sihorwala
Publishers : M/s. Scientific Publishers
5, New Pali Road, P.O. Box No. 91,
Jodhpur-342001, Rajasthan.

Soft bound, 110 pages, Price : Rs. 70/-

ISBN : 81-7233-128-2.

This book is a free translation of the manual No. M3 of IWWA on Chlorination and Use of Chlorinators written by Dr. A. D. Patwardhan — a highly experienced water & waste water engineer and Professor, Victoria Jubilee Technical Institute, Mumbai. It was felt that the contents of this very useful manual should receive wide and day to day application in the water works of our country IWWA therefore decided to translate its contents into different languages used in our country and the first choice naturally was Hindi, which is being used by a very large section of the population.

Dr. D. D. Ozha, a Hydro Chemist working in the Ground Water Board of Rajasthan State, being a dynamic member of IWWA of Jodhpur local centre who also has a flair for writing original books in Hindi language on technical subjects, took up this challenge and brought out this book which is not a literal translation of the original manual in English but a more or less independent book (of course based on the original manual). The book is written in a very lucid but simple form so that the subject can be understood by the water works personnel even at an operator's level.

It has also been vetted by Professor and Head of the Civil Engineering Dept. of S.G.S.I.S. & T. Indore and the Chairman of IWWA's Indore local centre Dr. T. A. Sihorwala (who is also its co-author). The book contains all information about Chlorine, its properties, forms in which it can be used for disinfection of water and method used for chlorination of Public Water Supplies both in urban and rural areas, effects of chlorine on environment including those which may be caused by Trihalomethanes etc. The past President of IWWA Shri S. S. Raghuvanshi — the Engineer-in-Chief of Public Health Engineering Department, M.P. State (Retd.) has written the foreword to this book and has recommended it for use by the water works personnel.

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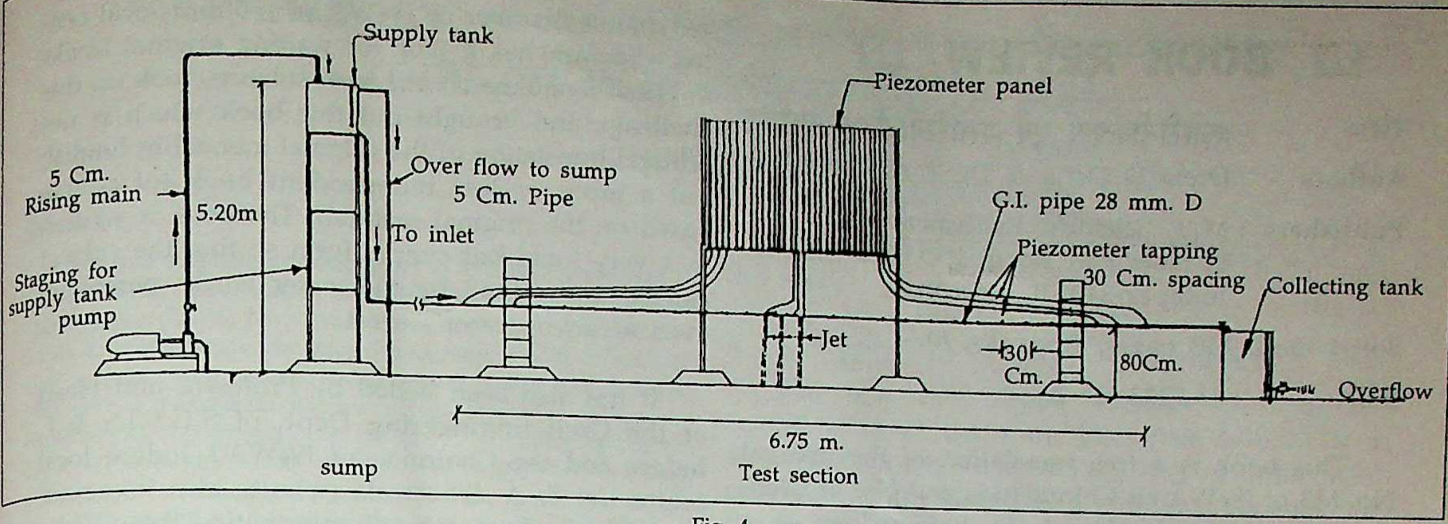
Supply tank
Piezometer panel
5 Cm.
Rising main
5.20m
Over flow to sump
5 Cm. Pipe
To inlet
G.I. pipe 28 mm. D
Piezometer tapping
30 Cm. spacing
Collecting tank
Staging for
supply tank
pump
Jet
30
Cm.
80Cm.
Overflow
6.75 m.
sump
Test section

Fig. 4

Schematic diagram of experimental set up

It is difficult to establish as to whether the equation based on energy principle is superior or that on momentum principle. A relationship between the energy and momentum principles can be established, such as, α = 2ß-Rd and the parameters can be determined by experimental investigation.

For the wider spacing of orifices i.e. 75 cm, the theoretical curves compare favourably with experimental curves than the closer spacings of orifices.

Bibliography :

1. Berlamont, J. and Van Der Becken, A, "Solutions for Lateral Outflow in Perforated Conduits." Journal of the Hydraulics Division ASCE, Vol. 99, No. Hyd., Sept. 1973.
2. Shivarudrappa. K. B., Sakthivadivel, R. etal. "Pressure Recovery in the Manifold". Diamond Jubilee Symposium — 1970, Central Water and Power Research Station.

Symbols :

A = Cross sectional area of the conduit
ax = Perforation area or slot area per unit length
a = ax/ao
C = Coefficient of discharge of perforation
D = Diameter of conduit
d = Diameter of orifice
f = Dimensionless friction factor
hx = Piezometric height at point x
ho = Inlet piezometric height
H = hx/ho
i = Flow conditions
hf = Head loss due to friction
l = Length of the conduit
Qx = Discharge in conduit at x
qx = Lateral outflow rate per unit length
Ux = Mean velocity
Uo = Inlet velocity
U = Ux/Uo
X = X/l
x = Longitudinal distance in flow direction
w = Width of slot
α = Energy correction coefficient
Rd = Pressure Recovery factor
V = Velocity of discharge through orifice

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(ii) Shivarudrappa's equation :

$$\frac{dH}{dX} = \beta N_o H^m I(X) - N_i I(X)^{ni} + (\beta - Rd)\ N_o H^m I(X)$$

A factor α, the energy correction coefficient, has been introduced in the former equation, whereas 'ß' the momentum correction coefficient and 'Rd' the pressure recovery coefficient have been included in the latter equation. If α and ß are assumed to be equal in the above equations, the two equations will be similar excepting for the presence of an additional term. In the latter equation, this extra term has been added to take care of the influence of the pressure recovery in the manifold. Hence, the equation developed by Shivarudrappa can be considered as an improvement over the other equation, as it considers the pressure recovery on the pressure distribution along the manifold. These two equations appear to consider all major factors and variables, involved in the manifold flow problem as compared to the earlier developed manifold flow equations.

Berlamont and Becken have introduced α in the inertia term to account for a change from the hydro static condition, existing in the manifold. If one assumes that this factor also takes care of turning losses at the branch points besides the energy correction, then, by comparing the two equations, one gets α = 2ß — Rd. This relationship leads to an apparent conclusion that manifold flow equation, developed on energy principle, contains only one empirical parameter, α, while the equation based on momentum principle has two empirical parameters, ß and Rd. The question whether the equation based on energy principle is superior to that based on momentum principle or vice versa, can be answered only if one can determine accurately the above three parameters either by theoretical or by experimental methods. As on date, no theoretical methods exist to determine the above constants, while attempts are made to evaluate the constants experimentally. In determining the constants experimentally, the author feels that the equation based on momentum principle lends itself more easily for determining Rd than that of determining α from energy principle for the reason that Rd governs only turning losses and ß the momentum correction coefficient takes into account both the turning losses and velocity distribution correction.

6. Experimental Studies :

Experimental studies were also done for determining the pressure distribution curves for a typical manifold flow problem and comparing the experimental results with those of the numerical solutions obtained from the above two manifold flow equations. The experimental setup used for this study consists of a G.I. conduit of 28 mm diameter, of 10 metres length connected to the supply tank with a head of 4.30 m. The flow and the pressure in the conduit were controlled by means of valves at the inlet and the outlet of the conduit. The central 6.75 m portion of the conduit was used as a test section with steady flow condition. Orifices of 6 mm were drilled at the bottom in the test section of the conduit at required uniform spacings, 4 mm dia. holes were drilled at the side of the test section of the conduit at 10 cm spacing for pressure tappings, connected to central manifold piezometric panel by flexible tubings. The discharges from orifices were measured. The outlet valve to the main conduit was closed making the type of conduit as a closed end manifold. The experimental set up is shown in Figure 4.

Experiments were conducted for orifice spacings of 75 cm and 18.75 cm and pressure distribution curves were plotted for these two case studies in a graph (Figure 2) along with the numerical solutions obtained from the two manifold flow equations. It may be seen from the plot that the pressure distribution curves drawn with the value of α = 1.34 in Berlamont's equation and ß = 1.02; Rd = 0.70 in Shivarudrappa's equation for orifice spacing of 75 cm are one and the same and they agree well with the experimental curve, thus proving the relationship obtained between energy and momentum principle viz., α = 2ß — Rd. For the closer spacing of orifices i.e. 18.75 cm, the theoretical curve does not give a good fit with the experimental curve for α = 1.00. A better fit can be obtained by changing the values of α.

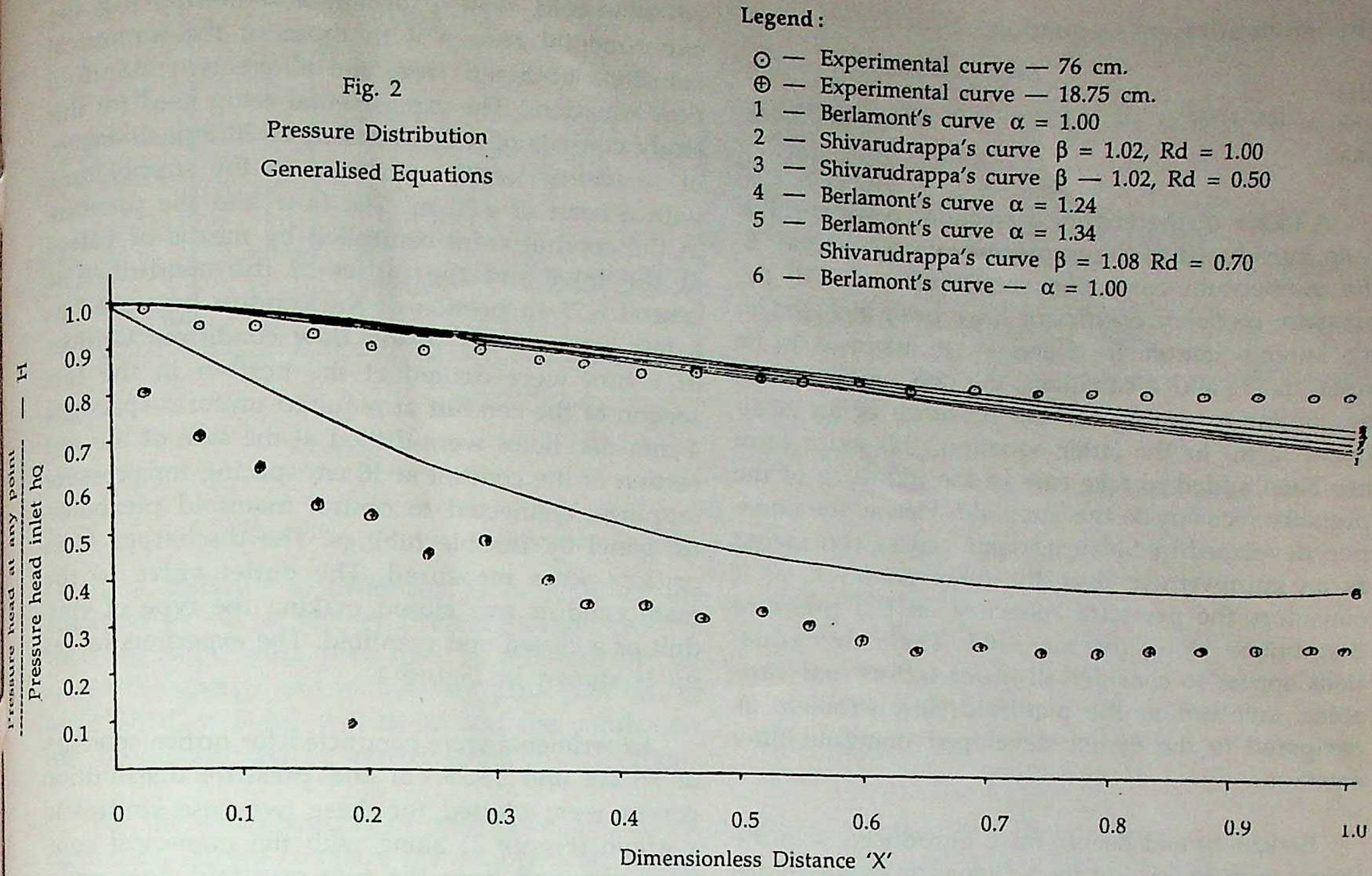
7. Conclusions :

Though a considerable number of equations have been formulated, only a few investigators have attempted a review on the manifold flow equations. This analysis considers the equations developed for simple dividing manifold for the pressure distribution. On a review of the development in this area, it has been found that the manifold flow equations developed by Jean Berlamont & Becken, based on energy principle and by Shivarudrappa *et al* based on momentum principle, for the pressure distribution along the manifold, are the two most sophisticated equations developed in this field, as they consider all major flow variables and flow conditions and also the losses at the branch points.

Fig. 2

Pressure Distribution

Generalised Equations



4.2 *Analysis of the Manifold flow equation developed by Shivarudrappa, K. B., et al:*

The authors have developed a differential equation for pressure distribution along the manifold for a constant cross sectional area, with a uniform perforation area, based on momentum principle. In this analysis, a phenomenon of pressure recovery 'Rd' in manifold, has been considered and a modified pressure distribution equation from that of Berlamont's equation, incorporating the effect of pressure recovery, has been derived (Figure 3). Assuming the manifold as a uniformly porous conduit, the authors have formulated the dimensionless pressure head distribution equation for the manifold as:

$$\frac{dh}{dX} = \beta N_o H^m I(X) - N_i I(X)^{ni} + (\beta\text{-}Rd) N_o H^m I(X) \ldots (2)$$

β = Momentum Correction Coefficient;

Rd = Pressure recovery factor;

Other symbols are as per equation (1).

Shivarudrappa's method

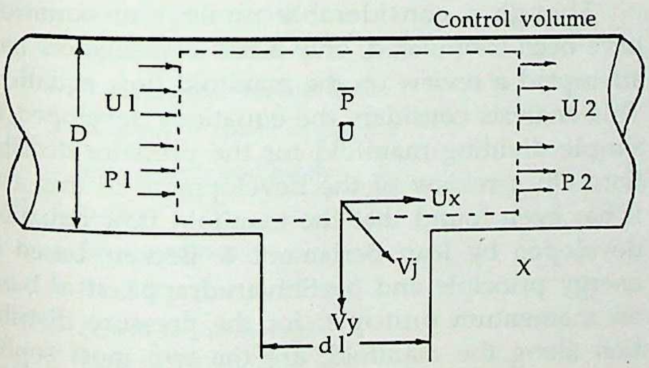


Fig. 3

Control volume for dividing flow branch point

The solution of the equation (2) can be obtained by performing numerical integration in a manner similar to that of Berlamont equation. The results of the analysis are plotted in a graph (Figure 2), for the values of the parameters $\beta = 1.02$, $N_o = 0.175$, Ni = 0.487, Rd = 1.00, 0.90, 0.70, orifice spacings = 75 cm.

5. Comparative Analysis of the Manifold Flow equations:

The two manifold flow equations are:

(i) Berlamont's equation:

$$\frac{dH}{dx} = \alpha N_o H^m I(x) - N_i I(x)^{ni}$$

indicate that the theories are based on either energy principle or momentum principle and in some cases on experimental studies. The manifold flow equations based on energy principle are: Keller J. D. (1949); Van Der Hegg Ziznen (1951); Howland W. E.(1953); Edwin Za'ak (1971): Jean Berlamont and Andre Becken (1973); The equations based on momentum principle are: Enger, M. L. and Levy, M. L. (1929); Horlock, J. H. (1956): Acrivos. A, Babcock, B. D., and Pigford. R.L. (1959), Bajura, R.A. (1971); Shivarudrappa, *et al* (1976). The equations developed by Jean Berlamont and Becken and Shivarudrappa *et al* appear to consider all different flow situations in the manifold problem and also all the flow variables involved.

4. Analysis of Manifold Flow Equations:

4.1 *Analysis of the Manifold Flow Equation Developed by Jean Berlamont and Becken:*

The authors' analysis of the manifold flow problem is based on the energy principle for a steady flow of a Newtonian, incompressible fluid in a horizontal pressurised conduit with a closed end, assuming a spatially continuous lateral outflow for the three following cases:

(i) Distribution of lateral outflow in a conduit of constant cross section and constant perforation area.

(ii) Distribution of the perforation area along the axis of the conduit to produce a uniform lateral outflow with a constant cross sectional area of the conduit.

(iii) Variation of the cross section of the conduit to produce a uniform lateral outflow, with the perforation area constant along the manifold.

In the present analysis, only the first case of manifold flow problem is considered. i.e., distribution of lateral outflow in a conduit of constant cross sectional and perforation area.

Berlamont's method

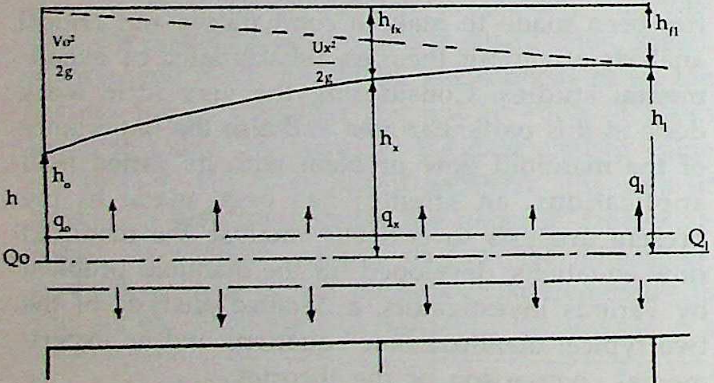


Fig. 1

Continuous Manifold

The wall of the conduit with a number of perforations is considered to provide a spatially continuous lateral outflow (Figure 1). For the propoundment of the theory, the authors considered the Bernoulli's equation for energy dissipation, Darcy-Weisbach formula for head loss and also three different types of flow conditions viz., laminar flow; turbulent smooth flow and turbulent rough flow for the friction factor based on Reynold's No., Blasius' law and Moody's diagram respectively. Nondimensionalising the equations with appropriate variables, the authors have developed the following dimensionless pressure distribution equation,

$$\frac{dH}{dx} = \alpha N_o H^m I(x) - N_i I(x)^{ni};\ i = 1, 2, 3 \ \ldots\ldots\ldots\ (1)$$

$$\text{in which } H = \frac{hx}{ho};\ N_o = 2\theta^2 K_o;\ N_i = c_i p_i \theta^{ni} K_o$$

$$K_o = \frac{U_o^2}{2gh_o};\ \theta = \frac{q_o}{Q_o};\ I(x) = \int_x^1 H^m dx$$

m = exponent variable;

α = velocity distribution correction coefficient.

The values of parameters, ci, ni, and mi for the three different flow conditions, adopted are as follows:

Flow	i	ci	ni	mi
Laminar	1	64	1	1
Turbulent Smooth	2	0.3164	7/4	5/8
Turbulent rough	3	1	2	1/2

The equation (1) is the differential equation for the pressure distribution along the manifold. Solutions to the above equation have been obtained numerically for each value of parameters α = 1.0, 1.24 & 1.34; No = 0.175 and Ni = 0.48 and for a fixed value of m = 0.5 and orifice spacing = 75 cm, using the Runge-Kutta method of fourth order with a step size of 0.05. The numerical values are plotted in a graph (Figure .2). For orifice spacing of 18.75 cm and α = 1.00, the solutions have been obtained.

A critical analysis of manifold fluid flow theories

Prof. Dr. S. Vasudevan*, Ph. D.

1. Introduction :

Manifold fluid flow analysis has, of late, been gaining importance in the field of Fluid Mechanics and many investigations have been made on the manifold flow problem by many scientists and research workers in areas of Mechanical engineering, Chemical engineering, Aeronautical engineering and Hydraulics engineering because of its varied applications potential.

Flow of fluids in conduits, having a number of discrete openings or a continuous slot or porous walls can be described as manifold flow. Manifolds can be generally classified into three categories, viz. (i) the simple dividing or blowing manifolds (ii) the simple combining or sucking manifolds and (iii) the combined manifold systems employing both dividing and combining flow manifolds simultaneously. Dividing type manifolds have applications in Gas burners and Heaters, Ventilating systems, Thermal discharge diffusers, Air conditioning, Grain aeration, Sprinkler systems, Navigation lock systems, Out fall diffusers, Off shore disposal, Aviation technology, Bio engineering etc. Combining type manifolds are employed in Fume removal, Boundary layer suction devices, Navigation lock systems, Pipe network systems etc. Combined manifold systems are employed in Super heaters and Refrigerant units.

2. Development of Manifold Fluid Flow Theories :

Studies on manifold fluid flow problems have been made by many investigators in various fields, since the beginning of the twentieth century. Most of the analyses of manifold flow problems made were based on experimental investigations as well as energy and momentum principles. Some of the important studies on this problem were made by Enger and Levy (1929), Keller (1949), Van Der Hegg Ziznen (1951), Howland (1953), Horlock (1956), Acrivos, Babcock and Pigford (1959), Bajura (1971), Za'ak (1971), Berlamont and Andre Van Der Becken (1973), Shivarudrappa *et al* (1976) etc.

Although there has been a number of theories developed for manifold flow problem by various investigators, each development is based on different assumptions and differs in the consideration of a number of flow variables involved in the problem. Among the various theories developed on this problem, only a few theories appear to consider all different flow conditions occurring in the manifolds as well as all the flow variables involved in the flow pattern.

3. Manifold Flow Problem :

The dividing flow or blowing manifolds have the following problems considered by various investigators — (i) For a constant cross sectional area of manifold and uniform distribution of perforation area or uniform width of a continuous slot along the length of manifold, the pressure distribution along the manifold and the factors contributing to the variation of pressure; (ii) For a constant cross sectional area of the duct forming the manifold, the distribution of perforation area or the width of a continuous slot at various points along the manifold so as to produce uniform discharge per unit length; and (iii) For uniform distribution of perforation area in the manifold, the variation of sectional area of the manifold to produce uniform distribution of discharge.

However, the present analysis is limited to the following specific situation for a single dividing manifold with the downstream end closed — for a constant sectional area and uniform distribution of perforation area or continuous slot of constant width, the pressure distribution along the manifold.

Though, so far, a number of theories have been developed by many investigators on the dividing flow manifold problem, with each researcher giving different type of equation, no systematic attempt has been made to make a comparative and critical analysis of various theories, substantiated by experimental studies. Considering the very little work done in this particular area and also the importance of the manifold flow problem with its varied field applications, an attempt has been made in the present analysis to critically analyse the manifold flow equations, developed for the manifold problem by various investigators, a detailed analysis of the two typical manifold flow equations and an experimental comparison of the theories.

An overview of the development of various manifold flow equations, by many investigators,

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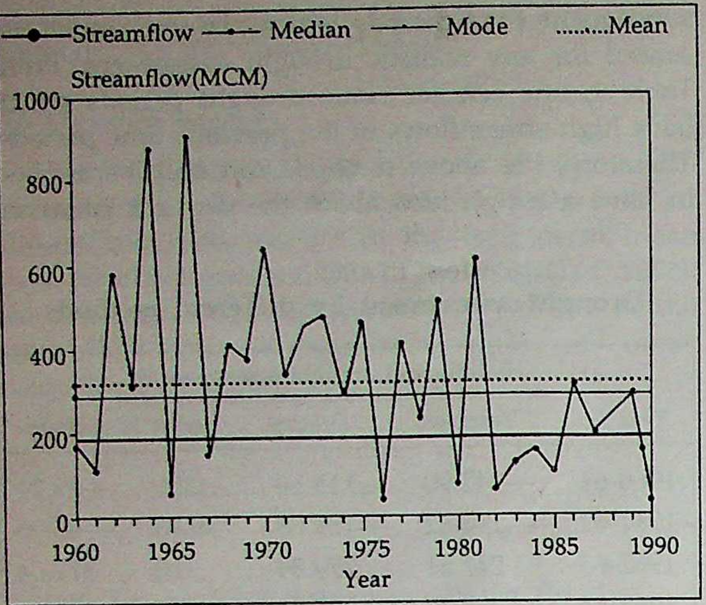

Fig. 1

Streamflow data with Truncation levels of different methods

this method. The weighting factor used in this method may be verified and improved to suit the field conditions.

Basically, hydrologic drought is defined as the deficiency in the availability of water in a place. All the above four methods estimate the deficiency as the difference between the actual flow in a month and the long term mean or median or mode as the case may be. The difference, thus calculated from the streamflow data alone may or may not be sufficient to indicate the deficiency of water availability and hence the drought. So, for hydrological drought assessment, other components of water availability such as surface water storage resulting from rainfall, ground water, etc. should be taken into account.

A debate is going on for a long time in hydrology as to whether it is better to use the mean or median or mode as the suitable parameter of central tendency for asymmetric probability distribution. For a symmetric probability distribution, mean, median and mode are equal. An analysis of all the factors for and against the use of each of them leads to using the mean as the best central value parameter. For very small samples, the use of median is justified because the mean is greatly affected by extreme values of samples. However, mode is a value which appears most frequently in the series. This may be suitable to represent a drought because there is a belief that anything less than the quantity to which people are accustomed is construed as a drought.

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Conclusions :

Based on the analysis and discussion made above, it is concluded that Yevjevich, Dracup and the newly proposed mode approaches could be used to give a rough idea about the hydrological drought situation in the study area with simple calculations. Herbst method is taking care of carry over factor. This method is also giving the time of onset, duration of drought and the termination of hydrological drought.

It is clear from above that each method is implying its own meaning and practicability. However, one needs to have an idea as to which method can predict the hydrological drought situation of an area as reasonably as possible. This becomes a difficult job since no common base of drought assessment for historical droughts is available.

Also, for hydrological drought assessment use of streamflow component alone is not sufficient to represent the water availability. Further research should take into account other surface and groundwater components for realistic assessment.

References :

1. Herbst, P. H., Bradenkamp, D. B. and Barker, H.M.G. (1966), "A Technique for the Evaluation of Drought from Rainfall Data", Jl. of Hydrology, Vol. 4, pp. 264-272.
2. Ravikumar, G. and Karmegam, M. (1992), "Implications of Drought Definitions", Proceedings of VIII APD-IAHR Congress, October 1992, Volume 1, pp. 91-100..
3. Government of India, (1973), "Integrated agricultural development in drought prone areas", Report of task force on integrated rural development, Planning Commission, Govt. of India.
4. Government of India, (1982), Report of task force on drought prone area and desert development programmes, Planning Commission, Govt. of India.
5. Yevjevich, V. (1967), 'An objective approach to definitions and investigations of continental droughts', Hydrology paper No. 23, Colorado State University, Colorado, USA.
6. Dracup, John. A., Lee K. S. and Edwing. G. Paulson (1980), 'On the definition of droughts', Water Resources Research, Vol. 16(2), pp.291-302.
7. Central Water Commission (1982), 'Brochure on Drought', Government of India, New Delhi.
8. Chow, Ven T. (1962), 'Statistical and Probability Analysis of Hydrologic Data;', Section 8.1., Hand Book of Applied Hydrology, McGraw Book Company, New York.

Pk is the respective long term mean rainfall for the month i-1(For example, if (i-1) represents January, k will take the value of 1)

$$Wi\text{-}1 = 0.1\ (1 + Pi * 12/Py) \qquad \text{................} (9)$$

Where Py is the annual mean rainfall.

Results and Discussion :

In the above methods, the mean and median (indicators of central tendency in any statistical distribution) are used as the basis to demarcate the drought periods. However, it is thought that the mode (which is also an indicator of central tendency) can as well be used as truncation level. Accordingly, an attempt is made to assess the hydrological drought situation using the mode and the results are presented here.

The proposed methodology is similar to that of Yevjevich and Dracup with the mode taken as the truncation level. The excess or deficit for a month is the difference between the actual streamflow of a month and the long term mode value for that month as given by,

$$Di = \frac{Fi - \hat{F}k}{\hat{F}k} \qquad \text{..............} (10)$$

where $\hat{F}k$ is the mode of long term streamflows for the respective month i.

The months with deficit values are assessed as hydrologic drought periods. The severity of a drought is the cumulative streamflow deficits occurring continuously.

The assessment of drought severity in the hydrological context was carried out employing all the above four methods (three existing and the one proposed in this study) for the Krishnagiri reservoir project in Krishnagiri taluk. The monthly streamflow data for 31 years (for the period 1960-91) is used and the results are presented in Table 1. The streamflow is plotted indicating the truncation levels of different methods, which is presented in Figure 1 on next page. The result of each method and its implications are discussed.

Yevjevich, Dracup and the mode approaches take into account the streamflow of a particular time period, completely neglecting the effect of antecedent conditions. They do not have carry over effect of excess/deficit of one time period to the subsequent time periods which are very much essential for any realistic drought assessment. From Table 1, one can see some drought periods which have high streamflows in the previous time periods. Therefore, the above methods can only be applied to have a rough idea about the drought situation.

TABLE 1
Drought assessment by different methods

Year	Hydrological drought assessment by			
	Yevjevich	Dracup	Herbst	Mode
1960-61	—147.90	—115.50	0.00	—23.24
1961-62	—190.62	—159.03	49.73	—65.96
1962-63	247.81	279.39	0.0	372.04
1963-64	-4.17	27.42	0.0	120.49
1964-65	546.09	577.68	0.48	670.75
1965-66	—249.72	—218.13	149.07	—125.06
1966-67	564.67	596.26	0.0	689.33
1967-68	—171.77	—140.18	47.16	—47.11
1968-69	94.23	125.82	0.42	218.89
1969-70	55.58	87.17	0.0	180.24
1970-71	298.90	330.49	0.0	423.56
1971-72	22.44	54.03	0.0	147.10
1972-73	129.49	161.08	0.0	254.15
1973-74	161.64	193.23	0.0	286.30
1974-75	—31.59	0.00	0.0	93.07
1975-76	131.25	162.08	50.56	255.91
1976-77	—261.81	—230.22	151.68	—136.35
1977-78	84.44	116.03	37.92	209.97
1978-79	—76.86	—45.27	0.0	47.80
1979-80	175.31	206.90	0.02	299.97
1980-81	—234.20	—202.61	120.67	—109.54
1981-82	278.94	310.53	32.91	403.60
1982-83	—243.99	—212.40	124.99	—119.33
1983-84	—177.90	—146.31	245.80	—53.24
1984-85	—154.46	—122.87	294.96	—29.80
1985-86	—210.46	—178.87	294.96	—85.80
1986-87	—14.56	17.03	118.80	110.10
1987-88	—117.20	—85.61	79.32	7.46
1988-89	—68.65	—37.06	19.83	56.01
1989-90	—154.01	—122.42	0.0	—29.35
1990-91	—280.91	—249.32	0.0	—156.25

However, Herbst method takes care of the excess/deficit of streamflow of a time period to be carried over to the successive periods, which is in accordance with reality. The onset, termination and the severity of drought are clearly determined by uses the long term mean value while the Herbst method uses the normal deficit.

(i) *Yevjevich method :*

Yevjevich developed the theory of runs which assesses drought on the basis of deficiency of streamflow with respect to the long term mean value as the truncation level. The excess or deficit for a month is the difference between the actual streamflow of a month and the long term **mean** value for that month as given by

$$Di = \frac{Fi - \overline{Fk}}{\overline{Fk}} \qquad \text{.................} (1)$$

where $\overline{Fk}$ = long term mean value for the respective month i

Fi = Streamflow for the month i.

In this method, the streamflow data is plotted as a continuous time series. The truncation line (long term mean value) will separate the excess and deficit periods. The run length is defined as the distance between two successive points on the truncation line where the series switch from one side to other. The run length between a downcross and the next upcross is termed as the duration of drought. The run sum is defined as the sum of the negative deviations, which is the drought severity.

(ii) *Dracup method :*

This method is similar to Yevjevich method except that the long term **median** value is used as the truncation level. The excess or deficit for a month is the difference between the actual streamflow of a month and the long term median value for that month as given by,

$$Di = \frac{Fi - \overline{\overline{Fk}}}{\overline{\overline{Fk}}} \qquad \text{.................} (2)$$

where $\overline{\overline{Fk}}$ is the long term median value for the respective month i.

The months with deficit values are assessed as hydrological drought periods. The severity of a drought is the cumulative streamflow deficits occurring continuously.

(iii) *Herbst method :*

Herbst (1966) developed a methodology with the long term mean deficit as the truncation level. Here the drought severity is determined by

$$Y = \frac{\sum_{i\,=\,M1}^{M2} (MDi - MMDi)}{\sum_{i\,=\,M1}^{M2} MMDi} \qquad \text{.................} (3)$$

$$X = YT \qquad \text{.................} (4)$$

MD is the Monthly Deficit;

MMD is the Mean Monthly Deficit;

Y is the average monthly drought intensity;

M1 is the month when the drought started;

M2 is the month when the drought terminated;

T is the duration of drought = M2-M1; and

X is the weighted index of drought

The onset and termination of drought periods are determined by comparing the deficiency of a month's effective rainfall with the long term mean monthly rainfall of that month with a twelve value sliding scale. This sliding scale is prepared as,

$$SS(R) = MMMR + (R-1)\ x \qquad \text{.................} (5)$$

where R will have values 1 to 12;

SS is the sliding scale;

MMMR is Maximum of mean monthly rainfall;

x is the monthly increment given by;

$$x = \frac{MAD-MMMR}{11} \qquad \text{.................} (6)$$

MAD is the Mean Annual Deficiency.

The excess or deficit rainfall of a month is calculated as the difference between the actual and the long term mean rainfall values of that particular month. This excess or deficit, after being multiplied by a weighting factor, is added to the subsequent, month's rainfall to get the effective rainfall of that month.

$$Ei = Pi + (Di\text{-}1 * Wi\text{-}1) \qquad \text{.................} (7)$$

$$Di\text{-}1 = (Pi\text{-}1 - Pk) \qquad \text{.................} (8)$$

Hydrological drought assessment using streamflow data

G. Ravimukar*, Dr. M. Karmegam**

Synopsis :

Hydrological drought is understood with reference to deficiency of water availability or streamflow. Hydrological drought assessment is carried out using Dracup, Yevjevich and Herbst methods which are based on the mean and median (indicators of central tendency in any statistical distribution) as truncation levels to demarcate the drought periods. As mode is also an indicator of central tendency, an attempt is made in this study to assess the hydrological drought situation using mode as the truncation level. Finally the need for a different database is stressed for hydrological drought assessment, as streamflow component alone is not sufficient to represent the water availability in an area. Also, the need for comparison of the methods used to identify a reliable method of prediction for the study area is stressed.

Introduction :

Drought is generally viewed as a sustained and regionally extensive occurrence of below average natural water availability, either in the form of precipitation, runoff or groundwater. Studies on the incidence of droughts as well as their prediction and undertaking measures to combat drought are extremely vital for countries like India with a predominantly agricultural economy. Droughts are categorised based upon the factors by which they are defined. The factors could be precipitation/ evapotranspiration/streamflow/soil moisture/vegetation/climatic or a combination of some of these. The National Commission on Agriculture (1976) classified droughts into three main categories as :

(i) Meteorological Drought : It is a situation when there is a significant decrease in precipitation from normal over an area.

(ii) Hydrological drought: Meteorological drought, if prolonged, results in hydrological drought with marked depletion of surface water and consequent drying up of lakes, reservoirs, streams and rivers and fall in the level of water table.

(iii) Agricultural drought : It occurs when soil moisture and rainfall are inadequate to support crop growth to maturity and cause extreme crop stress leading to loss of yield.

Govt. of India is identifying the drought prone areas based on the recommendation of the Task Force on Drought Prone Area Programme (1973, 1982). The basic criteria considered here are the yearly rainfall and the percentage of cultivated crop areas under irrigation. But drought assessment is not being carried out in any such identified places to justify these criteria. So an attempt is made here to assess the hydrological drought situation for Krishnagiri taluk, a chronic drought prone area, as declared by the Government of India.

Hydrological drought :

The hydrological aspects of drought are in general less attempted and poorly understood (CWC, 1982). Hydrological drought is understood with reference to deficiency of streamflow. For hydrological drought assessment, many definitions are available based on different truncation levels and base periods to demarcate deficiency and/or drought periods.

Hoyt(1938) defined drought as the period in which the actual flow of a natural stream in a selected number of days has a small probability of occurrence. Yevjevich (1967) suggested drought as the deficiency of streamflow with respect to the long term mean streamflow. Dracup (1980) defined it as the deficiency of streamflow with respect to the median of long term streamflows.

Joseph (1970) defined drought as a period with lowest mean discharge at a specified measuring point in a streamflow for 14 consecutive days during a climatic year beginning April 1. Oktay Guvan (1983) defined drought as the uninterrupted sequence of streamflows below an arbitrary level. Thambiannan (1990) quoted drought a three weeks to three months runoff deficit during the period of germination of vegetation.

In this study, hydrological drought assessment is carried out using Dracup, Yevjevich and Herbst methods. Dracup method assesses drought on the basis of deficiency of streamflow with respect to the median value (truncation level). Yevjevich method

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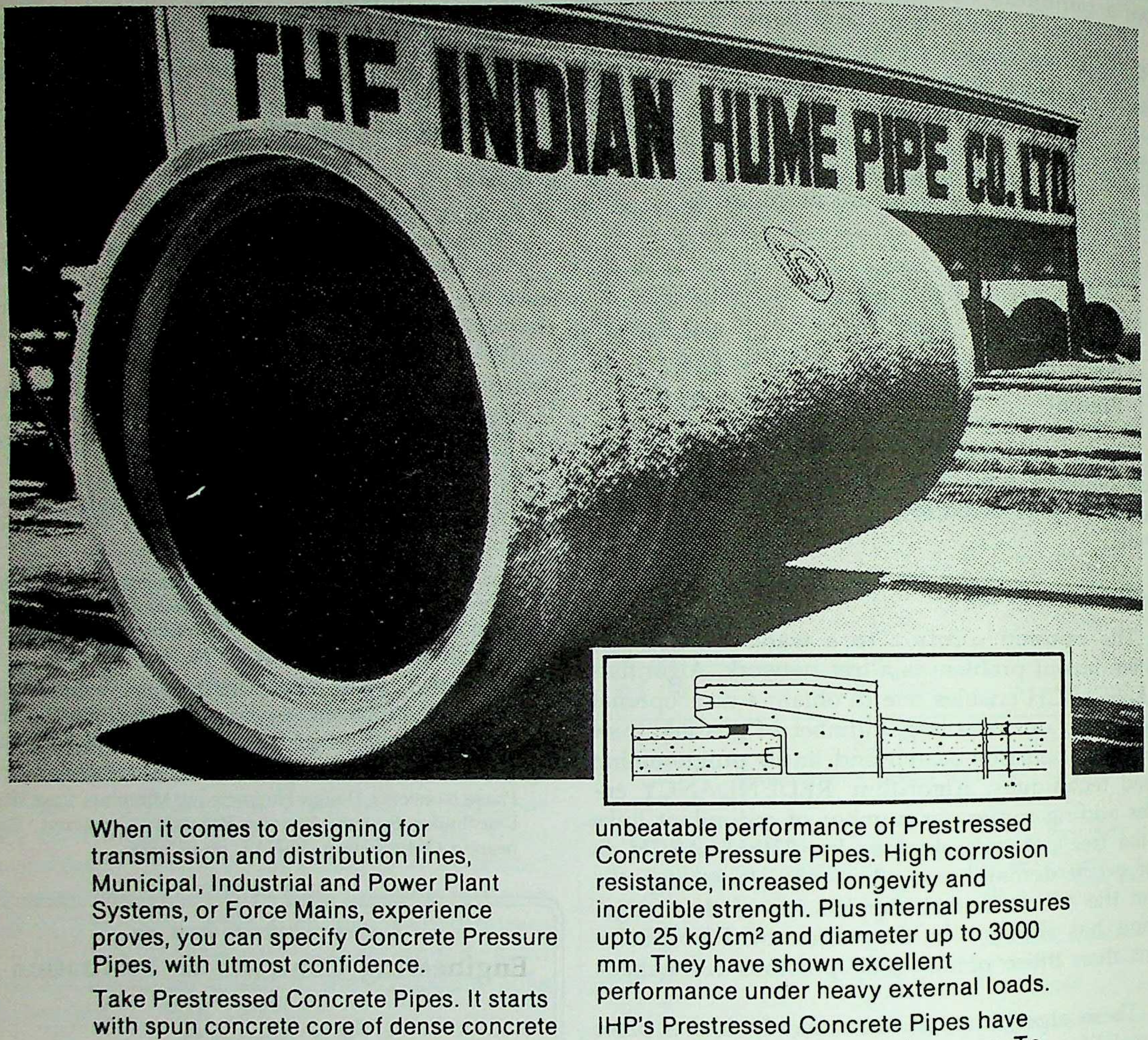

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Concept

units. For this tree layout, the algorithm REDUNDANCY gives link connecting nodes 5 & 7 as the only redundant link required. A 25 mm diameter was assumed for this link and the network was analysed using a network solver. All constraints were satisfied. The complete network is shown in Fig. 2. Since Fujiwara *et al* imposed the requirement that the hydraulic gradients for each link should be between 0.0005 and 0.05 and that every link should have a minimum flow of 1 cu.m/hr, no link could be eliminated. Thus to make a better comparison with Fujiwara's results both remaining links (4, 5) and (5, 7) were added to the tree. A diameter of 25 mm is assumed for these links and upon network analysis, the pressure constraints were found to be satisfied. The costs obtained by various researchers for this example problem are as follows:

Study	Cost
Alperovitz and Shamir (1977)	4,79,525
Quindry *et al* (1979)	4,41,522
Fujiwara *et al* (1987)	4,15,271
Present	4,03,667

The two algorithms were also applied on a 26-node network representative of real life situations. The reader is referred to Loganathan *et al* (1990) for details.

Conclusion :

The optimal solution to a water distribution system layout problem is a tree network. Algorithm TREESEARCH enables one to obtain a near optimal tree layout, out of a large number of possible trees through a heuristic search and linear programming based techniques. Algorithm REDUNDANCY enables adding minimum number of redundant links to the tree network obtained by TREESEARCH so that every demand node has two alternate paths from the source nodes. Application of these algorithms has shown that they offer lower cost solutions than those obtained by previous researchers.

These algorithms would certainly find a place in real life situations. For example, consider a case of supply of water from a Dam to various villages through a transmission network. In such situations, a large number of possibilities exist for connecting various villages from the Dam. Also, cost considerations would not allow a large number of redundant links.

In case of urban water supply systems a large number of redundant links are required to be present because of necessity of providing connections to consumers on every street. However, even in this case, it would be prudent to find a core tree through algorithm TREESEARCH first and add small diameter (say 100 mm or 150 mm) pipes on remaining streets. Experience of designing urban water supply systems has also shown that only few pipes are of large diameter and the remaining pipes are small diameter pipes.

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References :

Alperovitz, E., and Shamir U. (1977), 'Design of Optimal Water Distribution System,' Water Resources Research, Vol. 13, Dec, pp 885-900.

Bhave, P.R. (1979) 'Selecting Pipe Sizes in Network Optimisation by LP,' Journal of the Hydraulic Division, ASCE, Vol. 105, No. HY8, Aug., pp 1019-1025.

Quindry, G., Brill, E.D., and Liebman, J.C. (1981), 'Optimisation of Looped Water Distribution Systems.' Journal of Environmental Engineering Division, ASCE, Vol. 107, EE4, pp 665-679.

Rowell, W.F., and Barnes J.W. (1982), 'Obtaining Layout of Water Distribution Systems,' journal of Hydraulics Division, ASCE, Vol. 108, HY1 pp 137-148.

Fujiwara, O., Jenchaimahakoon, B., and Edirisinghe, N.C.P. (1987), 'A modified Linear Programming Gradient Method for Optimal Design of Looped Water Distribution Networks,' Water Resources Research, Vol. 23, No. 6, pp 977-982.

Shah, M.P. (1987), 'A Heuristic Method for the Optimal Design of Water Distribution Systems,' Master's Thesis, Virginia Polytechnic Institute and State University, Blacksburg, USA.

Loganathan, G.V., Sherali, H.D. and Shah M.P. (1990), 'A Two Phase Networks Design Heuristic for Minimum Cost Water Distribution Systems Under a Reliability Constraint,' Engineering Optimisation, Vol. 15, pp 311-336.

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to form a new tree is called an elementary transformation at a node. If after performing an elementary transformation the new tree is found to have a lower cost, it is preserved and an elementary transformation at a new node is performed. If the new tree has a higher cost, then a different tree is generated by deleting another link from the same loop. Algorithm ends when the transformations have been performed at every node.

It is to be noted that for the tree network, the optimisation program becomes a linear program as the flows in the links are known (Bhave, 1979). The optimal sizing and cost of the tree network in the above algorithm is obtained through the linear program. For a detailed formulation of algorithm TREESEARCH, refer Shah (1987).

Algorithm REDUNDANCY:

The tree network obtained from the Algorithm TREESEARCH is vulnerable because even if one link fails, many demand nodes may be cut off from supply. Thus it is necessary to provide loop forming redundant links in such a way that the demand nodes remain connected to the sources in case of a tree link failure. Loop forming links also provide better circulation and help avoid accumulation of sediments.

When a link in a tree fails, two connected components are created. Therefore any link from the Cotree (complement of the given tree from all physically possible links) having adjacent nodes in the respective connected components should qualify to be a candidate redundant link. Many reconnecting cotree links qualify as a redundant link for each, for failure of a link of the given tree. A judicious choice of redundant links would involve the selection of subsets of these reconnecting links associated with every tree link, i.e., to pick the most common of all reconnecting links such that two different paths are provided between sources and demand nodes. An algorithm to obtain the redundant links is elaborated in Shah (1987).

Having obtained the redundant links, the next step is to obtain pipe sizes for those links. Following procedure is used:

1. Assume minimum diameter for all redundant links.
2. Analyze the full network with a network solver — if all pressure requirements are met, STOP.
3. Revise the diameters of the selected redundant links, go to step 2.

Application:

A single source problem is selected from Alperovitz and Shamir (1977) who solved the problem using Linear Programming Gradient (LPG) Technique. Quindri *et al* (1981) and Fujiwara *et al* (1987) have successively improved the LPG technique and have obtained better solutions with lower costs. The network has 8 candidate links and 7 nodes (Fig. 1). It is fed by gravity from a constant head reservoir at node 1.

From this network fifteen different spanning trees can be generated. Two shortest path trees were used as initial guess for Algorithm TREESEARCH. The implementation of algorithm TREESEARCH for each guess resulted in the same optimal tree layout (Fig. 2), with a cost of 3,99,667

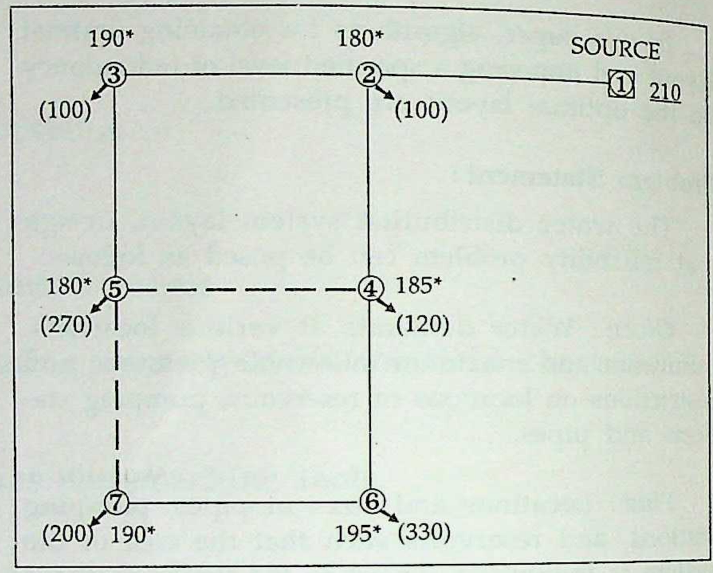
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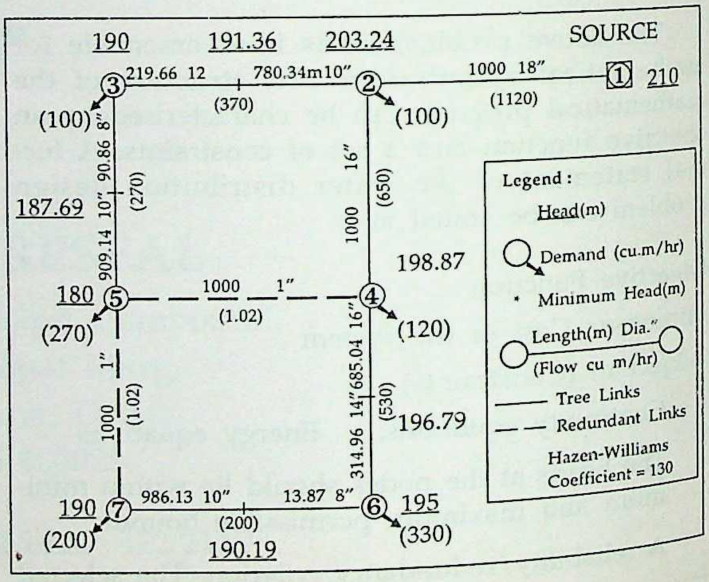
Fig. 1

Single source looped network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(200)
(200)
(330)
190.19
Legend:
Head(m)
Demand (cu.m/hr)
* Minimum Head(m)
Length(m) Dia."
(Flow cu m/hr)
Tree Links
Redundant Links
Hazen-Williams Coefficient = 130

Fig. 2

Single source tree network from TREESEARCH

A heuristic search technique for the optimal layout and design of water distribution systems with redundancy

M. P. Shah*

Introduction :

Past research in Water Distribution System Design has been focussed on the optimal sizing of pipe diameters for given fixed layout of the distribution network. Also, reliability or redundancy is generally forced into the system through an indirect constraint such as specifying minimum diameter or minimum flow in a link. An important aspect of pipe network planning and design is to obtain an optimal layout and address the issue of reliability and redundancy explicitly.

In this paper, algorithms for obtaining optimal layout and imposing a specified level of redundancy on the optimal layout are presented.

Problem Statement :

The water distribution system layout, design and reliability problem can be posed as follows:

Given : Water demands at various locations, minimum and maximum allowable pressures and restrictions on locations of reservoirs, pumping stations and pipes.

Find : Locations and sizes of pipes, pumping stations, and reservoirs such that the cost of the system is minimised subject to the limits on flows and pressures. Also, the network layout should be such that it satisfies a reliability criterion.

The above problem lends itself amenable for mathematical optimisation. The structure of the mathematical program can be characterised by an objective function and a set of constraints. A formal statement of the water distribution design problem can be stated as :

Objective Function :

Minimise : Cost of the system

Subject to (Constraints) :

Continuity equations; Energy equations

The heads at the nodes should lie within minimum and maximum permissible bounds.

A reliability/redundancy criterion. The selected criterion in this paper is that every demand node in the system should have two paths from source node(s).

For a detailed mathematical formulation of the above problem the reader is referred to shah (1987) and Loganthan *et al* (1990). Two main difficulties in solving this problem are : (1) The difficulty of modelling the redundancy constraint in mathematical terms (2) Even if the redundancy constraint is not included, obtaining a solution to the mathematical program is a formidable task. The objective function and the energy equations are nonlinear. In general, the presence of nonlinear equality constraints makes the feasible space nonconvex. Since the energy constraints are equality constraints, the problem becomes one of minimising a nonlinear objective function over a nonconvex constraint set. At present, no satisfactory algorithms are available which can guarantee a global optimum solution to this problem. Thus it was decided to decompose the overall problem into two sub problems. (a) to solve the problem without the redundancy constraint, (Algorithm TREESEARCH) (b) impose redundancy later (Algorithm REDUNDANCY).

Algorithm TREESEARCH :

It is known that the solution to this problem results in a tree layout by making the flows zero in the nontree links. Thus the problem consists in finding a tree layout and the pipe sizes of that layout. Two notable approaches to solving the problem are the linear Programming Gradient Technique (Alperovitz and Shamir, 1977; Quindry *et al*, 1981; Fujiwara *et al* : 1987) and the approach of Rowell and Barnes (1982). These approaches rely on mathematical optimisation. In this paper, an alternative way of obtaining the near optimal tree layout through a heuristic tree search technique has been used. The main advantages of the heuristic tree search technique over the gradient based technique are that the shortest path tree serves as a very good initial guess and it does not require computation of gradients or step sizes.

Addition of a link to a tree creates exactly one loop. Different trees can be generated by deleting links from the loop one at a time. Addition of a link at a node and deletion of a link from the loop

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* * *

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Both these will require Constitutional amendments for which some feel that the present political climate is not conducive. Besides, there are many practical difficulties for the centre to get involved in the day to day operation and management of large number of small and large projects across the country. Others feel that the Indian Constitution has evolved through numerous amendments as per requirement of the time, and water related amendments need to be considered.

Another possible option will be passing of more Central Legislations under Entry 56 of List-I to enable Centre to play more pro-active role both in regard to regulation towards optimum water development and in regard to avoiding of the interstate differences.

(l) *Extent of national responsibility to provide water to people :*

There cannot be two opinions about the responsibility of the state to provide water to meet the basic of human needs which is water for drinking and to a lesser extent for producing food. Commercial consideration cannot be dominant when it is a question of life and health of people. In the case of food, however one has the option of producing it elsewhere and then transport it to place of need.

(m) *Whether food self sufficiency should be national goal :*

Many economists propagating free market feel that one should engage in activities which one can do with the greatest efficiency. In order to be self sufficient in food, increased irrigation through long distance water transfers may be required. Investments in long distance water transfers may be economically less efficient as compared to say industrial and other commercial investments.

However many others feel that a nation of the size of India cannot afford to be not self sufficient in food requirements. The world trade in foodgrains is not large enough to meet the needs of a large country like India. World trade in rice for example is only 18 million tonnes at present. Large imports by India would affect the price stability. Infrastructural bottlenecks like port facility, shipping, roads, railways etc., are other constraints on increasing the trade in foodgrains.

(n) *Possibility of private funding/soft loan from International Agencies :*

Inter linking of rivers is going to be a gigantic proposal both in terms of size as well as in terms of investments. However, if the investments are spread over a number of years, annual investment will not be substantially higher than the present level for water resources sector and other poverty alleviation programmes. Private commercial fundings in this sector are unlikely in view of low returns and large gestation periods. Govt. has to be the major investor in such large national projects where the operation and management has to be governed by National considerations rather than commercial considerations.

Summary and conclusion :

Water being one of the key resources for overall development of a nation, its availability in adequate quantity, in all the seasons of an year and in different regions is highly essential. Unfortunately, nature has not been kind enough to provide our country with the availability of water so desired. It has therefore become necessary to undertake a number of engineering projects to store water of rivers (when available in large quantities) at suitably located vantage positions and transfer/transport it to other places within or even outside the watersheds of their river basins to satisfy the variety of needs pertaining to irrigation, hydro-power, water supply for domestic and industrial needs etc., in all the parts of the country.

Execution of such large and medium size storage and transfer (of water) projects, besides involving high engineering skills, adoption of modern techniques, and mobilisation of huge financial resources, raises a number of socio-economic, political, legal, and emotional issues within the society concerned, which will have to be addressed by the implementing agencies first before taking up programmes of execution of projects planned. These issues are however, not insurmountable, if the leaders in the society could be taken into confidence to educate the people and create atmosphere of understanding, co-operation and give and take rather than disputes and confrontation. The implementing agencies should therefore try to know, understand and consider sympathativally the different socio-economic issues involved and think of suitable solutions to help the people who are likely to be affected while executing these projects. It will thus be not difficult to store and arrange for Interbasin transfer of water — the essence of life and the key resource for achieving national development.

disputes involving only basin states, take decades to resolve. Accord involving non co-basin states would be even more time consuming and difficult to resolve.

Considering this, one view is that it may be more practicable for the Union Govt. to look after the interests of the non co-basin states.

The other view could be that the issues involved are better debated within the states and solutions acceptable to the people of the concerned states at large may be evolved to ensure their long term political commitment to the accord. The Union Govt. by its very nature cannot be sensitive to all local issues.

(f) ***Should the tribunals decide on the ultimate requirements of the basin and identify balance surplus waters :***

Presently the Inter State Water Dispute Tribunals allocate the available waters amongst the co-basin states perhaps without fully considering the ability of the basin states to utilise the waters in the foreseeable future. Thus, the possibilities of the surpluses being available to a State after meeting the ultimate requirements are not considered at present. This leads to a situation where considerable water from surplus basins may go unutilised to the sea.

Determining the surpluses which are likely to occur at the ultimate stage, however, is not easy. Water requirements for various uses will keep changing with time and technology available. No state would like either to make any commitment regarding its maximum requirements or to lose its rights on the surplus water forever.

(g) ***Long distance transfers vis-a-vis lifting :***

Long distance transfers are very costly. It may often be more attractive to utilise the water enroute rather than carry it over longer distances.

Lifting beyond a certain point may not be economically viable. Reliability of a system depending on power for lifting will be less than the one depending on gravity flow. Economic efficiency may provide a tool for deciding the trade off amongst the long distance water transfers vis-a-vis lifting and local use on high grounds.

But this would presume that water transfers are mere economic activities to be judged by the national economic efficiency. This point is debatable.

(h) ***Should normal criterion of economic analysis be applied for inter-basin transfers :***

Inter basin transfers are proposed for the benefit of drought prone areas which have no other source of water. Water for drinking may have to be either excluded from any economic analysis, or valued at the cost of alternatives, provided they exist. Also, given the large rural population and the lack of any alternative source of employment and income generation except agriculture, the employment benefits of water transfer may have to be valued at appropriate social costs.

Whereas water for domestic purpose can perhaps be taken out of the economic analysis, water for the purpose of producing food or providing employment cannot perhaps be given over-riding consideration. Same investment in less water consuming activity may be more paying. Decisions in such a situation may have to be based on economic criterion as capital is always a scarce commodity.

This will be more so when the capital in question will have to come increasingly from private sources. The debate perhaps needs to strike a balance between a pure national economic efficiency criterion, and a criterion justifying high cost transfers for providing livelihood.

(i) ***Is better water management a substitute to Water Transfers :***

Better management may become economically more attractive than bringing water through a costly Grid. However, the issue is: whether such wishful thinking should be reflected in our long term planning strategy.

(j) ***Inter basin transfers as a tool for socio-economic development and poverty alleviation programmes :***

Interbasin transfers will bring large additional area under irrigation and generate power, and will certainly meet the objective above.

(k) ***Need for Constitutional amendment :***

In case it is decided that the Centre should play an increased and pro-active role in planning and utilisation of water resources of the country including through inter basin transfers, then some of the important options available are :

1. Transfer of the subject of development and management of water resources from State list (List-II) to Union list (list-I).

over-riding national priorities. It also provides that the Centre would take care of the water allocations required in the National interest in the process of the allocations. It also states that the claims of a non basin state in the basin water could be considered in the scheme of allocation, in the national interest, to the extent these are found to fit in the scheme of allocation.

Points for debate on interbasin transfer of water :

Paragraphs below give points which need careful consideration through debates to arrive at a concensus.

(a) ***Whether water development and management can be planned in administrative/political unit like a state basin or basin state :***

A total basinwise planning approach towards increasing the national well-being alone, ignoring statewise or regional consideration may not be unacceptable. For example, such a policy may make the upstream states suffer larger submergence, while reducing their irrigation benefits through costly canals in rugged topography in favour of simpler canals in plain lands lower down. Even if more efficient in terms of national economy, such actions may be objectionable. The fact that states in India represent not only political administrative units, but also sub-cultures which need to be preserved and developed, may give more credence to such objections.

Thus, while the basin has to remain a national planning unit, the regional, non-co-basin and state interest would also have to be safeguarded. The issue is complex, and considerable debate may be necessary to guide the location specific solutions.

(b) ***Are interbasin transfers within the basin state to be allowed or encouraged :***

A state can plead that once a certain quantity of basin water is allocated to it, it is free to use it anywhere in the state including outside the basin. Another state may plead that only the inbasin needs be either considered or allowed.

In the case law in India, mostly (but not always) the former view of allowing the state to transfer water outside the basin has been favoured. Also, traditionally, many projects, when the irrigation is within the boundaries of the owner State (or group of States), but outside the basin, have been planned. Nagarjunasagar, Tungabhadra, Ukai, Sardar Sarovar etc. can be quoted in this regard. If the latter view has to prevail, it has to consider these ground realities as historical abberations. It has also to disregard the fact that if the basin is a natural geographic unit, the State also is a political administrative unit taking a holistic view within its territory. The latter view, however, would strongly support the basinwise planning concept.

(c) ***Should water be made available to non-basin States through long distance inter basin water transfers :***

The National Water Policy adopted by the National Water Resources Council states that water should be made available to water short area by transfer from other areas including transfers from one river basin to another.

It will however be difficult to prioritise the needs of the non co-basin states. There may be more than one state asking for a share in the surpluses available elsewhere. Techno-economic viability alone cannot be the criterion for deciding on the share of each non co-basin state. Other factors, like size of the water deficits, availability of alternative sources of water, possibility of savings in the available inbasin water through better water management etc., also need to be considered.

(d) ***Has the Union Government to play any role in regard to the inter basin transfers :***

The National Policy Guidelines for Water Allocation of Inter State Rivers amongst States was recently considered in the meeting of the Third National Water Resources Council held on 6th February, 1996. The draft guidelines inter alia propose that centre will be a party to look after the National interests like environmental concerns, pressing need of non co-basin states, needs dictated by international relations and obligations, needs of national waterways for navigation. Thus Union Govt. may be a party in any Inter state water dispute to look after the various interests including long distance transfers which may be necessary to meet the pressing need of non co-basin states.

(e) ***Is it practicable to decide long distance inter basin transfer through an accord of concerned states :***

One important aspect of long distance transfer of water is that it involves one or more non co-basin states including the target state. The conflicting interests of the basin states, target states and en route states are not easy to resolve. Inter state water

Diversion to Pulichintala and Nagarjunasagar will need 105 MW and 1647 MW, respectively for lifting.

Krishna to Pennar : Out of the 14000 Mcm of water received at Nagarjunasagar through Inchampalli-Nagarjunasagar link, 12000 Mcm is proposed for diversion through Nagarjunasagar — Somasila link and the balance is utilised for taking over part command of Nagarjunasagar LBC in exchange. The quantum of water reaching the Somasila reservoir on Pennar after considering utilisation under part command of Nagarjunasagar RBC in exchange as well as for additional enroute irrigation in the basin covering streams between Gundlakamma and Pennar and losses in conveyance is around 9800 Mcm.

As the entire command of existing Nagarjunasagar Project under Nagarjunasagar LBC and RBC are proposed to be taken over by the link waters, an equal quantum of water as an exchange will have to be diverted from suitable locations viz., Srisailam and Almatti across the river Krishna to the needy areas. About 2300 Mcm is proposed to be diverted from Srisailam through Srisailam-Proddatur link which would deliver water at the proposed barrage near Proddatur. In addition, about 2000 Mcm quantity is proposed for diversion from Almatti through Almatti-Pennar link to cater for enroute irrigation in Krishna and Pennar basins. This link was not envisaged in the National perspective.

Pennar to Cauvery : About 9500 Mcm of water is proposed to be transferred through a single link. The National Perspective had envisaged two links connecting Pennar and Cauvery. The link outfall is at Grand Anicut on Cauvery. After accounting for enroute requirement for irrigation and water supply to Madras City and transmission losses, about 5000 Mcm of water will be reaching Grand Anicut. Out of this quantity about 3000 Mcm is proposed to be utilised in Cauvery delta.

Cauvery to Vaigai : Out of the 5000 Mcm reaching Upper Anicut on Cauvery about 2000 Mcm is proposed for diversion through Cauvery — Vaigai link for utilisation in Cauvery, Vaigai and streams between Vaigai and Vaippar.

A number of alternative proposals are also under study based on which some modifications may be suggested in the link proposals. Though the surpluses in Mahanadi and Godavari as assessed now are much less than earlier envisaged, additional waters are likely to become available when Brahmaputra-Ganga link and Ganga-Mahanadi link are considered.

Total funds and time requirements :

The additional irrigation potential on implementation of inter linking proposals under Peninsular and Himalayan components would be around 25 million Ha from surface waters and 10 Million Ha from increased use of ground water. The approximate cost of capital works, at current prices, involving inter linking proposals for irrigation benefits, can be roughly assumed as Rs. 50,000 crores for Peninsular Component and Rs. 1,00,000 crores for the Himalayan Component. Branch canals, distributaries, minors field channels etc., would cost about Rs. 1,00,000 crore. Similarly the cost of power component involving a total of about 30000 MW, part of which would be in Nepal and Bhutan, would be of the order of Rs. 80000 crores. The execution of all these works may take about 40 years including detailed investigation, design etc. Thus the yearly investment on capital works for Himalayan and Peninsular component may be around Rs.8500 crores.

Issues involved in Inter-basin transfers :

Inter basin transfers involving long distance link canals do not have unsurmountable technical problems. Modern technology would help overcome them. Pumping large quantities of water over fairly high heads during monsoon when flood water is generally silt laden is one such problem. Development in hydraulic machines are well advanced in this regard. Tunnelling high embankments, long river crossings, minimising seepage losses etc., are some other difficult problems but with solutions. Main objection to the implementation of interbasin transfers and large storage may come from environmentalists regarding submergence of forests etc., It is seen that out of total forest cover reduction since independence, only 12 per cent can be attributed to storages created. The overall environment is seen to improve in the vicinity of these storages. Health and living standards of people are seen to improve.

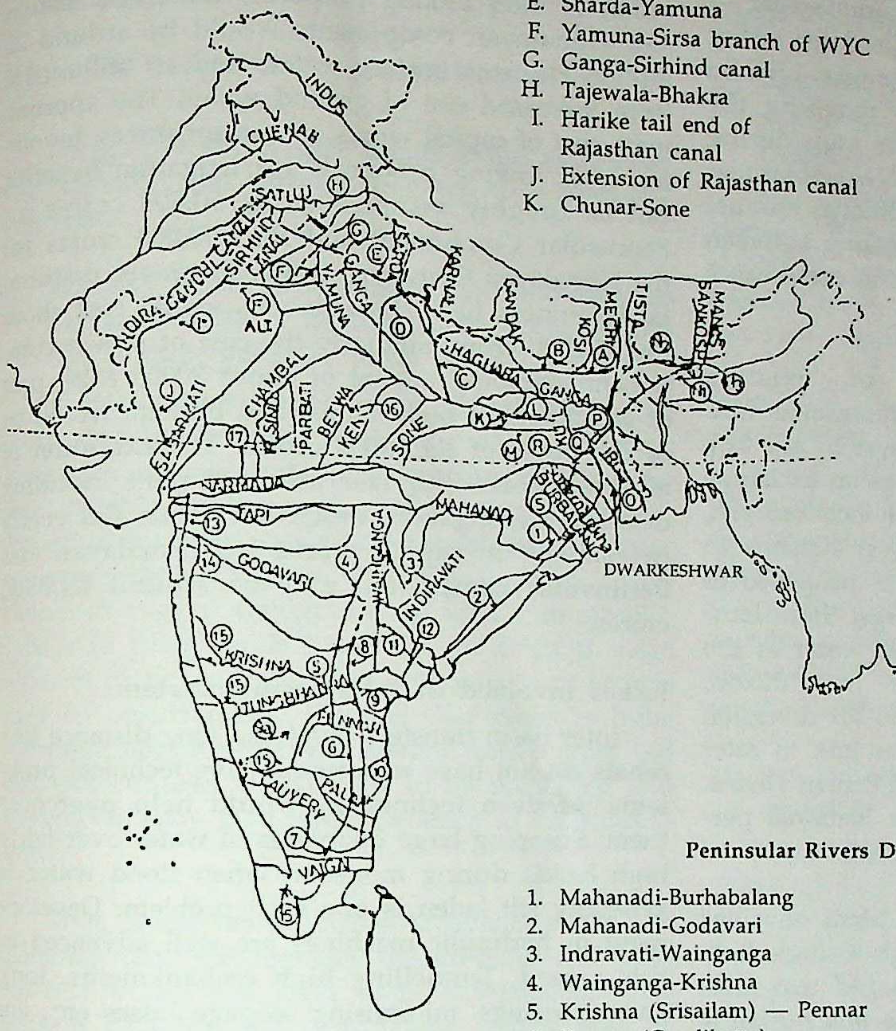
The Policy Guidelines for water allocation amongst states was considered in National Water Resources Council meeting held on 6-2-1996 under the Chairmanship of the Hon'ble Prime Minister.

The policy provides that a State shall be free to utilise the allocated water in any part of its territory unless specific restrictions are warranted from

Proposed Links Under National Perspective plan

Himalayan Rivers Development Component :

A. Kosi-Mechi
B. Kosi-Ghagra
C. Gandak-Ganga
D. Karnali-Yamuna
E. Sharda-Yamuna
F. Yamuna-Sirsa branch of WYC
G. Ganga-Sirhind canal
H. Tajewala-Bhakra
I. Harike tail end of Rajasthan canal
J. Extension of Rajasthan canal
K. Chunar-Sone
L. Sone Barrage-Kiul
M. Sone Dam-Southern Tributary
N1. Brahmaputra-Ganga (Alternative-I)
N2. Brahmaputra-Ganga (Alternative-II)
N3. Brahmaputra-Ganga (Alternative-III)
O. Farakka-Sunderbans
P. Farakka-Durgapur
Q. Durgapur-Dwarkeshwar
R. Durgapur-Subernarekha
S. Dwarkeshwar-Mahanadi


INDUS
CHENAB
SATLUJ
SIRHIND CANAL
RAJASTHAN CANAL
ALT
YAMUNA
GANGA
SARDA
KARNALI
GANDAK
GHAGHRA
KOSI
MECHI
TISTA
MANAS
SANKOSH
CHAMBAL
SINDH
PARBATI
BETWA
KEN
SONE
SABARMATI
NARMADA
TAPI
MAHANADI
GODAVARI
WAINGANGA
INDRAVATI
KRISHNA
TUNGBHADRA
PENNAR
PALAR
CAUVERY
VAIGAI
DWARKESHWAR

LIBRARY
Gurukul Kangri Vishwavidyalaya
HARDWAR

Peninsular Rivers Development Component :

1. Mahanadi-Burhabalang
2. Mahanadi-Godavari
3. Indravati-Wainganga
4. Wainganga-Krishna
5. Krishna (Srisailam) — Pennar
6. Pennar (Gandikotta)
7. Cauvery — Vaigai
8. Godavari (Inchmpalli) Krishna (Nagarjunasagar)
9. Krishna (Nagarjunasagar) Pennar (Somasila)
9.(a). Krishana (Almatti) — Pennar
10. Pennar (Somasila) Palar-Cauvery
11. Godavari (Inchampalli) Krishna (Pulichintala)
12. Godavari (Polavaram) Krishna (Vijayawada)
13. Par-Tapi-Narmada
14. Damanganga-Tansa
15. West flowing rivers of Kerala & Karnataka (West-East links)
(I) Pamba-Achankovil-Vaigai/Vaippar
(II) Netravati-Hemavati
(III) Bedthi-Varda
16. Ken-Betwa
17. Kalisindh-Chambal

Legend :

International Boundary ....
Basin Boundary ....
River ....
Links .... Ⓐ

irrigation in the Srikakulam and Visakhapatnam districts of Andhra Pradesh proposes to deliver about 6500 Mcm of water to Godavari Delta.

Godavari to Krishna : The gross surplus available in the Godavari basin considering 6500 Mcm of water received from Mahanadi would be 21500 Mcm (15000 + 6500) which is contemplated for diversion to the Krishna through three links — (1) diversion of 1200 Mcm of water through Polavaram — Vijayawada link for supplementation of the Krishna delta requirement, (2) about 4370 Mcm through Inchampalli — Pulichintala link for taking over part commands under Nagarjunasagar LBC and Nagarjunasagar RBC as exchange and (3) around 14000 Mcm of water into the Nagarjunasagar reservoir after accounting for transmission losses and enroute irrigation requirement.

weather flows of the Ganga. Surplus flows available on account of inter-linking of Ganga and Yamuna are proposed to be transferred to the drought areas of Haryana, Rajasthan and Gujarat. The scheme will also enable large areas in South-Uttar Pradesh and South Bihar to obtain irrigation benefits from the Ganga with a moderate lift of less than 30 m. Further, all lands in Tarai area of Nepal would also get irrigation apart from generation of about 30 million kw of hydro-power in Nepal and India. It will also provide flood moderation in the Ganga Brahmaputra system. With this proposal, about 14.0 million ha.m. of additional water would be available from these river systems for irrigating an estimated 22 million ha. in the Ganga Brahmaputra basin, apart from Haryana, Punjab, Rajasthan and Gujarat. It would also provide 1120 cumecs (40,000 cusecs) to Calcutta Port and would provide navigation facilities across the country. The scheme will benefit not only parts of India but also our neighbours — Nepal and Bangladesh. Planning and implementation of this scheme will have to include Nepal, Bhutan and Bangladesh as they also are part of the same hydrological unit.

Peninsular River Component :

Amongst the Peninsular rivers, the Mahanadi and Godavari have sizeable surpluses after meeting the existing and projected needs of the State within these basins. It was therefore, proposed to provide terminal storages on Mahanadi and Godavari rivers to divert surplus flows of Mahanadi to the Godavari system and to further transfer surplus from the Godavari System to water short rivers namely, Krishna, Pennar and Cauvery. The link from Mahanadi to Godavari will be along the east-coast and will not involve any lift. The link between Godavari and Krishna will be partly by gravity and partly, in the ultimate stage, by lifts of the order of 120 M (maximum). The transfer of waters would enable irrigation in drought areas of Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu by successive exchange.

The second component of this proposal is to divert a part of the waters of the west-flowing rivers of Kerala to the east for irrigating the drought areas of Tamil Nadu, apart from bringing new areas under irrigation in Kerala.

The third component is to construct storages and to inter-link small rivers flowing along the west-coast, north of Mumbai and South of Tapi. This will enable partial release of waters from Tapi and Narmada which will enable extension of irrigation to Saurashtra and Kutch areas. It will also enable provision of extra water to meet the growing needs of metropolitan area of Mumbai as well as providing irrigation to the coastal areas in Maharashtra.

The fourth component envisages inter-linking of the southern tributaries of the Yamuna like the Ken and the Chambal in addition to construction of small storages on intermediate tributaries and a dam on the Yamuna at Panchnad. This will enable irrigation in Ujjain and Indore areas of Madhya Pradesh as well as Upper areas in Rajasthan.

The proposal of Peninsular River Development will enable additional use of about 8.4 million ha.m. of water to benefit the States of Orissa, Andhra Pradesh, Maharashtra, Karnataka, Tamil Nadu, Madhya Pradesh etc. This will provide additional irrigation benefits of over 13 million ha.

National Perspective Plan :

The distinctive feature of the National Perspective was that the transfer of water is essentially by gravity and only in small reaches by lifts not exceeding 120 m. The scheme was *prima facie* found to be technically feasible and economically viable when compared to the present cost of development of irrigation facillities. The technology required is already known and tried in our own country and does not involve experimentation or research.

Initially priority was to be given to the development of storages and gravity links in order to exploit maximum benefits of hydro power generation in initial stages and at the same time extend irrigation benefits to large areas. This could be later on followed by lift components.

The National Water Development Agency was set up in 1982 by the Govt. of India as an Autonomous Society fully funded by it to study the feasibility of the National Perspective Plan. Initially, work of Peninsular Component of the National Perspective Plan was entrusted to the Agency. The Himalayan Component was subsequently entrusted to the Agency during 1990-91.

Some of the important link proposals framed by the above Agency are described below :

Mahanadi to Godavari : A quantum of 8000 Mcm has been proposed for transfer through Mahanadi — Godavari link taking off at Manibhadra on Mahanadi. The link after providing for enroute planning for water supply in meeting projected requirement atleast upto 2050 A.D. needs to be done now and availability matched with progressive increased requirements. Part of the requirement can be met by recycling the waste water. Balance requirement of water will have to be met through long distance transfers.

All these demands will have to be satisfied through adoptions of techniques for management of demand and supply. Some of the methods which can be adopted for this purpose are given below:

Demand management :

1. Irrigation
   - ☐ Drip
   - ☐ Sprinkler
   - ☐ Change in cropping pattern
   - ☐ Evaporation control
   - ☐ Reduction in canal losses
2. Industries
   - ☐ Recycling
   - ☐ Improved technology
3. Domestic supply — Effluent treatment and its use for irrigation, horticulture, forestry etc.

Supply management :

1. Artificial recharge
   - ☐ Recharge through irrigation
   - ☐ Designed artificial recharge
2. Inter basin transfers
3. Desalination of sea water
4. Rain fall by cloud seeding.

Some examples of Inter Basin Transfer of water in India :

Long distance inter basin transfer of water is not a new concept and has been in practice in India for over five centuries. The Western Yamuna Canal and the Agra Canal built in Mughal times are examples. Water was carried from the Himalayas to the distant parts of Punjab, U.P. and Rajasthan. The Kurnool Cuddappah Canal (1860-1870) and Periyar Vaigai (1896) are other good examples of inter basin water transfers executed in India in the 19th Century.

In the present century, Rajasthan Canal Project diverts waters from the Himalayas to the deserts of Rajasthan. The project comprises of a huge multi purpose dam constructed across the Beas river at Pong, a barrage at Harike and a grand canal system. Other important inter basin water transfer schemes in the country are the Parambikulam-Aliyar Project, Telugu Ganga, Sardar Sarovar etc.

Planning for Inter Basin Transfers :

Proposals for a National water grid for transferring surplus water available in some regions to water-deficit areas have been made from time to time. Two proposals put forth earlier in the seventies were Garland canal and National water grid.

The Garland canal proposal of Captain Dastur was examined by two committees of Experts from Central Water Commission, State Governments and Professors from IIT and Roorkee, who were of the opinion that the proposal was technically unsound and economically prohibitive. Preliminary studies carried out by the Central Commission (around 1979) indicated that the cost of the Dastur proposal was about Rs.12 million crores. The scheme was, therefore, given up.

Proposals for a National Water Grid by Dr. K. L. Rao were examined by the Central Water Commission and found to be grossly under-estimated. It was also observed that the scheme would require large blocks of power (5 to 7 million kw.) for lifting water. It will also have no flood control benefits. Therefore, the proposal was not pursued further.

There were many other proposals for small regional interbasin transfers. All these proposals were at best, very preliminary and conceptual. No thinking of engineering practicability seems to have gone into most of these and these can hardly qualify as alternatives worth serious consideration.

In 1980, the then ministry of irrigation (now water resources) Govt. of India formulated the National Perspective Plan which comprises two components, namely;

(i) Himalayan Rivers Development and

(ii) Peninsular Rivers Development.

Himalayan Rivers Component :

The Himalayan Rivers Component envisages construction of storages on the main Ganga and the Brahmaputra rivers and their principal tributaries in India and Nepal so as to conserve monsoon flows for flood control, hydro-power generation and irrigation. Inter linking canal systems will be provided to transfer surplus flows of the Kosi, Gandak and Ghagra to the west. In addition, Brahmaputra-Ganga Link will be constructed for augmenting dry

TABLE 1

Water Resources Potential of River Basins of India

Sl. No.	River Basin	Average Annual Availability: Water Resources Potential (km³)	Average Annual Availability: Per Capita (m³)	Utilisable Surface Water (km³)	Ground Wàter Potentia (km³)	Present diversions: Surface	Present diversions: Ground
1.	Indus	73.3	1757	46.0	25.5	40	17.34
2.	Ganga-Brahmaputra-Meghna	1110.6	2833	274.0	201.4		
	(a) Ganga	525.0	1473	250.0	171.7		48.64
	(b) Brahmaputra	537.2	18417	24.0	27.9		0.78
	(c) Barak	48.4	7646	—	1.8		
3.	Godavari	110.5	2026	76.3	46.8	38.0	6.87
4.	Krishna	78.1	1312	58.0	26.6	47.0	6.50
5.	Subernarekha	12.4	1392	6.8	2.2		0.13
6.	Cauvery	21.4	666	19.0	13.6	18.0	5.71
7.	Brahmani-Baitarani	28.5	2696	18.3	5.9		0.31
8.	Mahanadi	66.9	2546	50.0	21.3	17.0	1.07
9.	Pennar	6.3	648	6.9	5.0	5.0	1.63
10.	Mahi	11.0	1057	3.1	7.9	2.5	
11.	Sabarmati	3.8	421	1.9	—	1.8	
12.	Narmada	45.6	2855	34.5	11.9	8.0	2.03
13.	Tapi	14.9	1091	14.5	8.2		1.96
14.	West Flowing rivers from Tapi to Tadri	87.4	3194	11.9	9.5		
15.	West Flowing rivers from Tadri to Kanyakumari	113.5	3539	24.3	8.8		
16.	East Flowing rivers between Mahanadi & Pennar	22.5	919	13.1	22.8		
17.	East Flowing rivers between Pennar & Kanyakumari	16.5	383	16.7	20.9		
18.	West Flowing rivers of Kutch & Saurashtra including Luni	15.1	631	15.0	13.9		
19.	Area of inland drainage in Rajasthan desert	negl.	—	—	—		
20.	Minor rivers draining into Myanmar (Burma) & Bangladesh	31.0	14616	—	—		
	Total :	1869.3	2214	690.3	452.2		

Demand for Metropolitan water supply :

Most of the mega cities and urban centres are already water short, inspite of priority being given to urban and industrial water supply requirements. Already long distance water transfers have come into existence for metropolitan water supply. Delhi gets partial supplies from Bhimgoda on Ganga (200 kms) and Bhakra on Sutlej (300 km), Mumbai gets water from Vaitarana, Bhatsa etc. (90–120 km), Madras water supply is being augmented from Srisailam on Krishna (500 km). Farakka barrage and feeder canal carries water supplies to Calcutta. The

Inter basin transfer of water for National Development — Problems & Prospects

Synopsis :

Water Resources Day is observed during the months of April — May every year in our country for the last 10 years to focus attention of all the concerned professionals — ie Water Engineers, Socio-economists, Administrators etc. — and also the common man, on the importance of different aspects of development of water resources in our country. The nodal agency which initiates and guides the observance of this day is the 'Indian Water Resources Society (IWRS)'. The theme for this year's (1996) water resources day was 'Interbasin transfer of water for National Development, problems and prospects'. Indian Water Works Association observed this day at its different centres and organised lecture-meetings and debates on subjects related to the theme above. This article is an abridged version of the theme paper prepared and circulated by IWRS on this occasion. It is felt that it will be quite interesting and very much useful to the readers of this journal.

Introduction :

Water is one of the most important resources required for the development and prosperity of any country. Distribution of water resources in the world and so also in our own country is however highly uneven both in space and time. The rain-fall which feeds the sources of water in our country every year is seasonal so that the rivers carry high flows during the rainy monsoon season between June to September but dwindle down during the remaining part of the year. Rivers in the northern regions of the country originating in the Himalayan mountains receive water during summer season also, due to melting of snow on these, while some of the rivers in the southern peninsula get it (of course in small quantity) during the winter season due to the rain fall brought down by north westerly monsoon winds. Table No. 1 (appearing on next page) is giving the annual availability of water in different river basins in the country indicating the great imbalance of water in these. Hence regular inter basin links for transfer and distribution of water be established by undertaking inter state projects and which will also help foster day to day co-operation leading to national solidarity and creating a feeling of oneness. The plans for implementing such projects will of course require huge financial outlays and many technical, social and legal issues will have to be sorted out before taking up these.

Need for inter basin transfers :

Though river basin could be a basic unit for water resource planning, this may not lead to the optimal utilisation of the surplus water resources in various regions of the country. There are many basins in the country which would be surplus in water resources even in the ultimate stage of development, while other basins would already be facing situation of water shortages. For meeting the shortages in deficit regions, (even long distance) interbasin transfers of water may be necessary. This will lead to equitable distribution and optimum utilisation of our water resources.

The need or otherwise of inter basin transfers will depend on the futuristic projections for the demand for irrigation, population, Metro water supply etc. The scenario in our country in this respect is as follows :

Demand for irrigation :

The population of India is expected to stabilise at 1500 to 1800 million by 2050 AD and that would require about 450 million tonnes of food grains annually at the present level of consumption. To meet the demands of the country reasonably well, we will have to plan for a production of not less than 500 million tonnes of food grains by 2050 AD. The present productivity of irrigated land is about 2.5 tonnes/ha. and less than 0.5 tonnes/ha. for rain fed lands. Assuming that these levels can go up to 3.5 tonnes/ha and 1.0 tonne/ha. respectively by 2050 AD, it is imperative that we create an irrigation potential of at least 130 million ha. for food crop alone and 160 million ha. for all crops, to be able to meet the demands of the country by 2050 AD.

The Hydro power demand vis a vis Himalayan storages :

At 40% requirement of power from hydel sources for peaking, hydel power requirement will be around 3.3 million MW which is far higher than the 84000 MW of estimated hydel power potential of the country. In such a scenario the large potential available in Nepal and Bhutan would become attractive and perhaps inescapable from the point of view of power alone. Once these large storages in the Himalayas become a reality, the Himalayan links would become feasible. Studies including investigations of interlinking proposals have, therefore, to be ready for implementation by that time.

Director, NEERI, Nagpur for permission to publish the paper.

References :

1. Bhattacharya S. K., Urban Domestic Water Supply in Developing Countries, CBS Publishers & Distributors, Delhi.
2. Bassin, J. K., Gupta, I. and Gupta, A. (1992), Graph Theoretic Approach to the Analysis of Water Distribution System, *Jour. Indian Water Works Assoc.*, XXIV(3), 269-276.
3. Gupta, I., Bassin, J. K., Gupta, A. and Khanna, P. (1993), Optimisation of Water Distribution System, *Env. Software*, 8, 101-113.
4. Jain, A. K., Mohan, D. M. and Khanna, P. (1978), Modified Hazen-Williams Formula, *Jour. Env. Engg. Division*, ASCE, 104(EE1), 137-146.
5. Manual of Water Supply and Treatment (1991), CPHEEO, Ministry of Urban Development, Govt. of India.
6. Patwardhan, S. S. (1981), Universal metering for Urban Rural towns — A case study, *Jour. Indian Wat. Works Assoc.*, XIII(1), 51-59.
7. Report on Evaluation of Engineering, Economic, Health and Social Aspects of Intermittent Vis-a-vis Continuous Water Supply Systems in Urban Areas (1994), National Environmental Engineering Research Institute, Nagpur.

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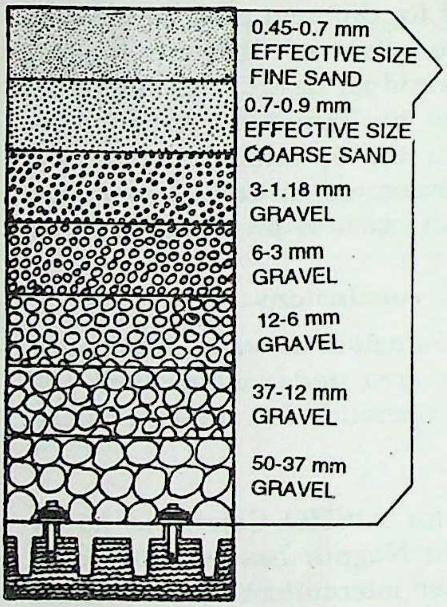

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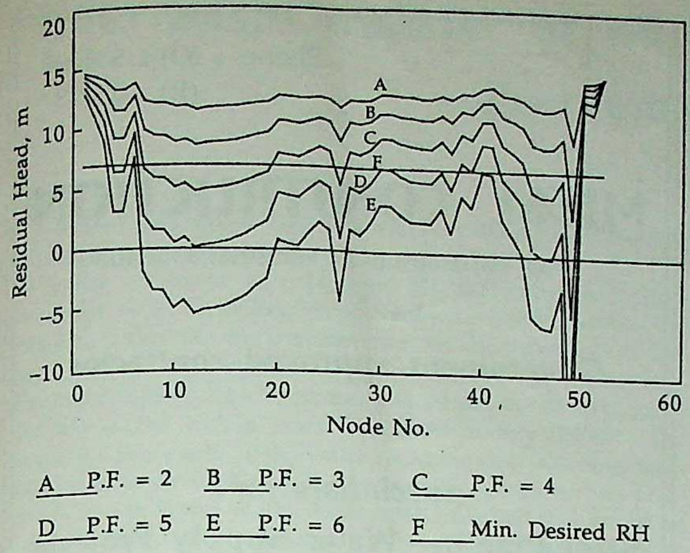

Fig. 8

Residual Heads for Optimal Network with P.F. 2 for Different P.F. — Shankar Nagar, Nagpur

Further, the cost of the existing system has been worked out to be 21.08 lakhs. Optimal designs have been obtained for the existing network configuration with source pressure of 1.5 Kg/cm², existing demands and for a minimum residual head of 7 m as per CPHEEO guidelines (Ref. 5) with different peak factors varying from 2.0 to 6.0. The cost of optimal network with increasing peak factor is presented in Fig. 7.

The optimal design with a peak factor of 2.0 has been further analyzed for different peak factors with a view to study the effect of different loading conditions on nodal residual heads. The number of demand nodes below the minimum specified residual head (7 m) for the optimal design with a peak factor of 2 is presented in Table 3 while the comparison of residual heads is presented in Fig. 8.

Salient findings and conclusions :

The findings of evaluation of water distribution network in the study area under intermittent and continuous modes of operation are presented hereunder.

The peak factor for AWHO Colony in Jaipur and Shankar Nagar in Nagpur has been found to be 4.38 and 2.03 under intermittent mode whereas under continuous mode, it reduced to 1.66 and 2.02, respectively. In Shankar Nagar area, the reason that the peak factor did not differ significantly under the two modes of supply can be attributed to long duration (16 hours) of supply under intermittent mode.

The existing system at AWHO Colony, fulfills the design criteria of minimum residual head at all the nodes. Analysis indicates that even with a peak factor of 11, the distribution system satisfies the minimum residual pressure requirement. The existing system at Shankar Nagar with a peak factor of 2 does not fulfill the required minimum residual pressure of 7 m at all the nodes. Analysis of the system with higher peak factors indicated that the situation substantially deteriorates with respect to nodal residual pressure. With a peak factor of 3, while the residual head generally ranges between 2 and 5 m, the residual head at 2 out of 51 demand nodes becomes negative, i.e. water will normally not reach the surrounding areas.

Water consumption under intermittent mode of supply for AWHO Colony and Shankar Nagar was about 34.2% and 15.4 less than that with continuous mode. Unaccounted for water (UFW) under intermittent mode has been found to be 23.4% and 24.5% of the total quantity of water supplied in Jaipur and Nagpur study areas respectively. Under continuous mode, UFW increased to 44.1% and 29.1% respectively.

The saving in cost by adopting optimal design with peak factor 2 with the service standards and design criteria mentioned earlier is 41.6% and 12.4% compared to that of the existing distribution networks for AWHO Colony and Shankar Nagar respectively. Increase in cost is dependent on the size of the distribution zone and the carrying capacity of the existing system. For AWHO Colony, it varied between 4.75 and 5.53 lakhs while for the Shankar Nagar area, it varied between 18.46 and 24.11 lakhs.

Though the respondents were satisfied with IWS, all favoured CWS. The studies have further shown that from economic and public hygiene considerations also continuous mode of supply should be preferred.

Acknowledgement :

Financial support provided by the Central Public Health and Environmental Engineering Organisation (CPHEEO), Ministry of Urban Development, Government of India for this study is gratefully acknowledged. Thanks are due to the officials of Public Health Engineering Department, Jaipur and Nagpur Municipal Corporation, Nagpur for their kind co-operation in providing relevant data for the study. The authors are grateful to Dr. P. Khanna,

Maharashtra Water Supply & Sewerage Board — Schedule of Rates (1991-92).

Further, optimal designs have been obtained for different peak factors between 2.0 and 6.0 with a minimum residual head of 8m, for the existing network layout with a source pressure of 1.9 Kg/cm², C_R value of 0.8 and projected water demands. The cost of optimal network with increasing peak factor is presented in Fig. 4.

The optimal design (peak factor 2) has been further analyzed for different peak factors (3, 4, 5, 6) with a view to study the effect of different loading conditions on nodal residual heads. The number of demand nodes below the minimum specified residual head (8 m) for the optimal design for different peak factors is presented in Table 3 while the comparison of residual heads is presented in Fig. 5.

Shankar Nagar, Nagpur :

The network has been calibrated with field measurements of flow and pressure and it has been found that with a C_R value of 0.6, the observed and computed pressures were within +0.1 Kg/cm² at 6 out of 7 observation nodes. Analysis of the existing network has been carried out with a source pressure of 1.5 Kg/cm² as measured during the survey, and existing demands. For continuous supply, the observed peak factor is nearly 2.0. The existing network has been analyzed for different peak factors of 2, 3, 4, 5 and 6 with a view to simulate the intermittent mode of supply and to study the effect of different loading conditions on nodal residual heads. The residual nodal heads at demand nodes for different peak factors are shown in Fig. 6.

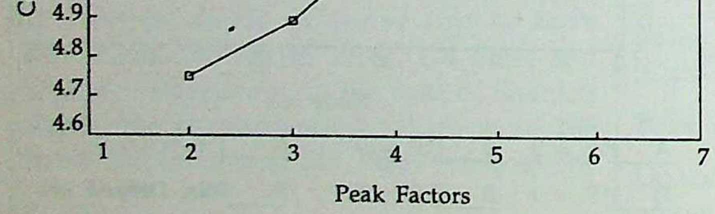

Fig. 4

Optimal Cost of Network for Different Peak Factors — AWHO Colony, Jaipur

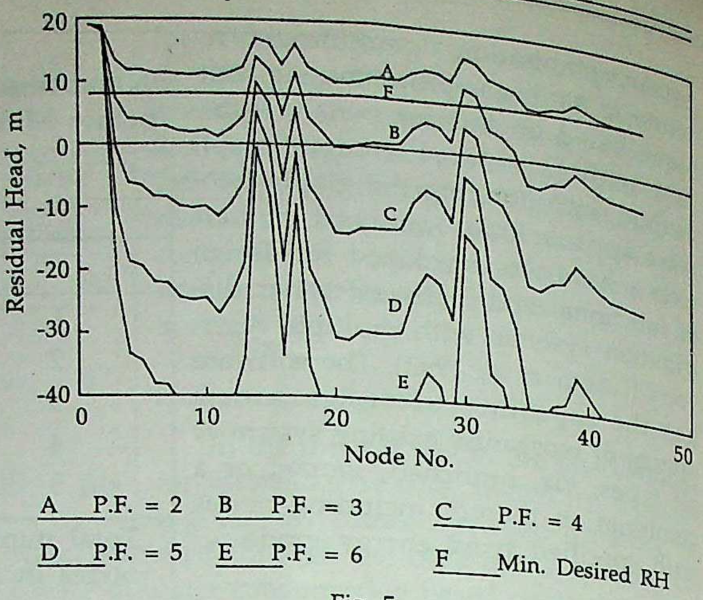

Fig. 5

Residual Head for Optimal Network with P.F. 2 for Different P.F. — AWHO Colony, Jaipur

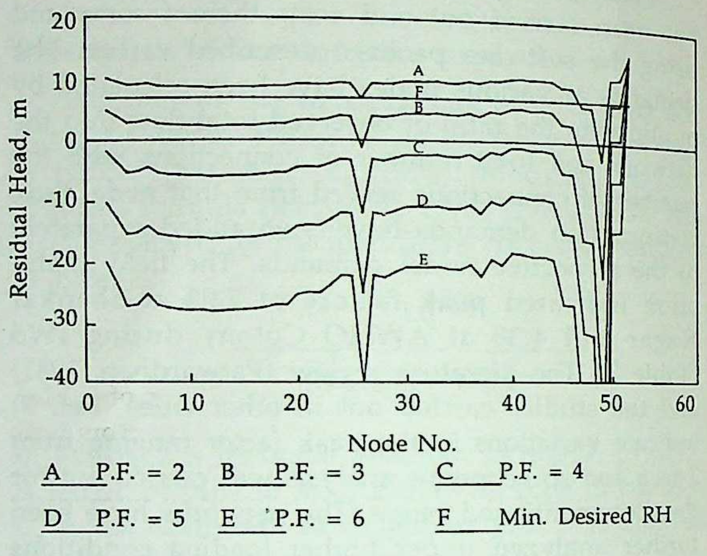

Fig. 6

Residual Heads for Existing Network for Different P.F. — Shankar Nagar, Nagpur

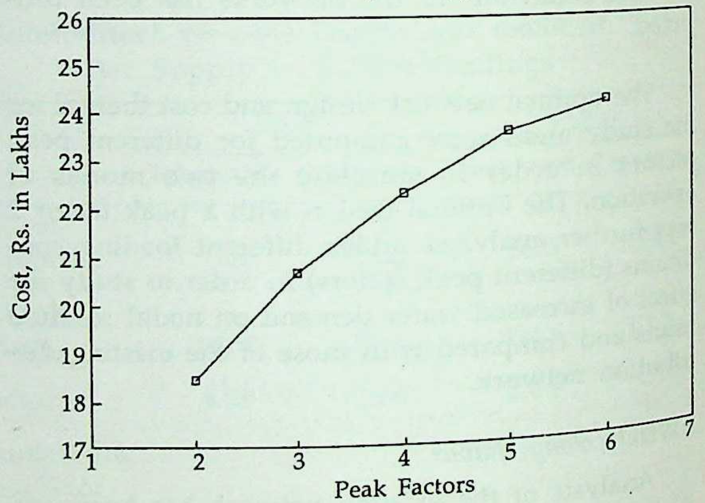

Fig. 7

Optimal Cost of Network for Different Peak Factors — Shankar Nagar, Nagpur

An optimisation algorithm with recourse to nonlinear programming technique based on interior penalty function with Davidon-Fletcher-Powell method, incorporating the graph theoretic approach for analysis of networks, has been developed for design of functional and least-cost water distribution systems with multiple reservoirs (Gupta *et al,* 1993). The software has the capability to design a new system or reorganise existing system of all types, viz. branched, looped or a combination thereof including nodes with specified fixed energy grade.

TABLE 3

Number of nodes in the Optimal Network (Peak Factor 2) below Minimum Residual Head under Higher Peak Factors

Serial No.	Peak Factor	No. of Demand Nodes below Minimum Residual Head for Optimal Design	
		Jaipur	Nagpur
1	2.0	0	0
2	3.0	38	1
3	4.0	41	19
4	5.0	43	42
5	6.0	43	45
Total number of demand nodes in the Network		44	51

Economic evaluation of the distribution system :

Analysis of the existing distribution networks has been carried out and costs thereof computed using the software package described earlier. The demands at various nodes have been calculated by multiplying the ratio of observed total flow into the network and total number of connections with the number of connections served from that node. Bulk consumption demands have been added separately to the respective nodal demands. The field evaluation indicated peak factors of 2.03 at Shankar Nagar and 4.38 at AWHO Colony during IWS (Table 2). The literature review (Patwardhan, 1981) and the studies carried out in other cities (Ref. 7) indicate variations in the peak factor ranging from 2 to 6 and so economic analysis was carried out for the aforementioned range. The networks have been further analyzed under higher loading conditions (higher peak factors) with a view to simulate the conditions obtained in intermittent mode of supply and the behaviour of the networks has been projected.

The optimal network design and cost thereof for the study areas were computed for different peak factors in order to simulate the two modes of operation. The optimal design with a peak factor 2 was further analyzed under different loading conditions (different peak factors) in order to study the effect of increased water demand on nodal residual heads and compared with those of the existing distribution network.

AWHO colony, Jaipur :

Analysis of the existing network has been carried out with a source pressure of 1.9 Kg/cm² based on the observations of the field study under the existing water demands. During calibration of the network the observed nodal pressures matched with computed values within 0.1 Kg/cm² with C_R value of 0.8. The network has been analyzed with different peak factors with a view of simulate the intermittent operation of the system and study the effect of different loading conditions on nodal residual heads. Residual nodal heads at the demand nodes for different peak factors are presented in Fig. 3. The minimum residual head has been taken as 8 m since the height of the overhead tanks for double storeyed buildings is 7.5 m from GL. It has been observed that the network performance is satisfactory even with a peak factor of 11. Thus, it is concluded from the analysis that the existing network has the capacity to cater to more water demand than the anticipated future demand. This is also confirmed by the low peak factor (1.66) observed during CWS. The cost of the existing system has been worked out to be 8.13 lakhs as per

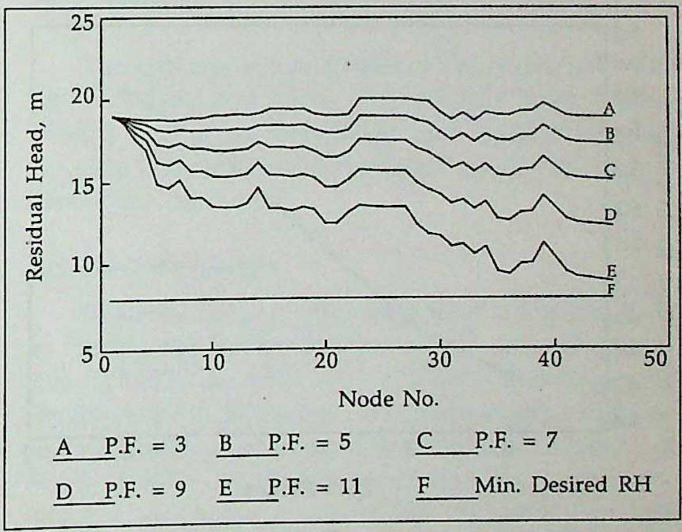

Fig. 3

Residual Head for Existing Network for Different P.F. — AWHO Colony, Jaipur

TABLE 1

Per Capita Water Consumption in Study Areas Summary Data

Study Area	Water Consumption (LPCD) Intermittent Mode Mean	Median	SD	Continuous Mode Mean	Median	SD
AWHO Colony, Jaipur	174	149	90	193	186	87
Shankar Nagar, Nagpur	209	188	119	232	235	108

during the period of water supply to the study area. The flow recorded included leakages and unaccounted for water. For measurement of pressure(s) 6 to 7 points were selected (Figs. 1 & 2) such that they were spread over the distribution district selected for study and representative of the pipeline network and topography of the study area. Care was also taken to include those nodes in the area where consumers had problems of residual pressure. Pressures were measured every ½ hour at the selected nodes during the water supply timing.

Water Consumption :

Intermittent Water Supply :

Out of 206 metered house service connections in AWHO Colony, Jaipur, 195 water meters were found in working condition while in Shankar Nagar, Nagpur, out of 330 metered house connections surveyed, 214 meters were in working condition. Accordingly, the working meters only have been considered for estimation of per capita water consumption. The values of water consumption less than 40 lpcd or greater than 500 lpcd, were discarded as outliers for statistical analysis. Since the frequency distribution of per capita consumption was observed to be skewed, the median was taken as the measure of central tendency as it is insensitive to outliers. The median, average and standard deviation of per capita water consumption for AWHO Colony under intermittent mode of water supply have been calculated as 149 litres, 174 litres and 90 litres respectively. In the case of Shankar Nagar, the corresponding values were 188 litres, 209 litres and 119 litres respectively.

Continuous Water Supply :

The median, average and standard deviation of per capita water consumption under continuous mode of water supply for AWHO Colony have been calculated as 186 litres, 194 litres and 87 litres respectively. The corresponding values for Shankar Nagar have been calculated as 235 litres, 232 litres and 108 litres respectively. The summary data on per-capita consumption under intermittent and continuous water supply modes is presented in Table 1.

Unaccounted For Water :

In the present study, the unaccounted for water has been estimated by calculating the difference between quantity of water supplied through the bulk meter and the estimate of water consumption based on average consumption per person per day. The percentage of unaccounted for water based on total supply is presented in Table 2.

Description of the Software used :

Analysis of the network has been carried out using a software based on graph theory developed at NEERI (Bassin *et al*, 1992). Modified Hazen-Williams formula (Jain *et al*, 1978) given below has been employed for calculating the frictional headloss in pipes.

$$f = \frac{Lq^{1.8099}}{994.62\ C_R^{1.8099}\ D^{4.8099}}$$

in which, f is frictional headloss in a pipe in m; L is length of pipe in m; q is flow in pipe in cu.m/s; C_R is the coefficient of roughness and D is internal diameter of pipe in m.

TABLE 2

Intermittent vis-a-vis Continuous mode of Water Supply — Salient Findings

Particulars	Jaipur Intermittent	Jaipur Continuous	Nagpur Intermittent	Nagpur Continuous
Duration of supply (hours)	5.5	24.0	16.0	24.0
Total supply (Cum/day)	197.0	299.5	924.6	1093.0
Peak factor	4.38	1.66	2.03	2.02
Unaccounted for water as % of total supply based on average Consumption	23.4	44.1	24.5	29.1

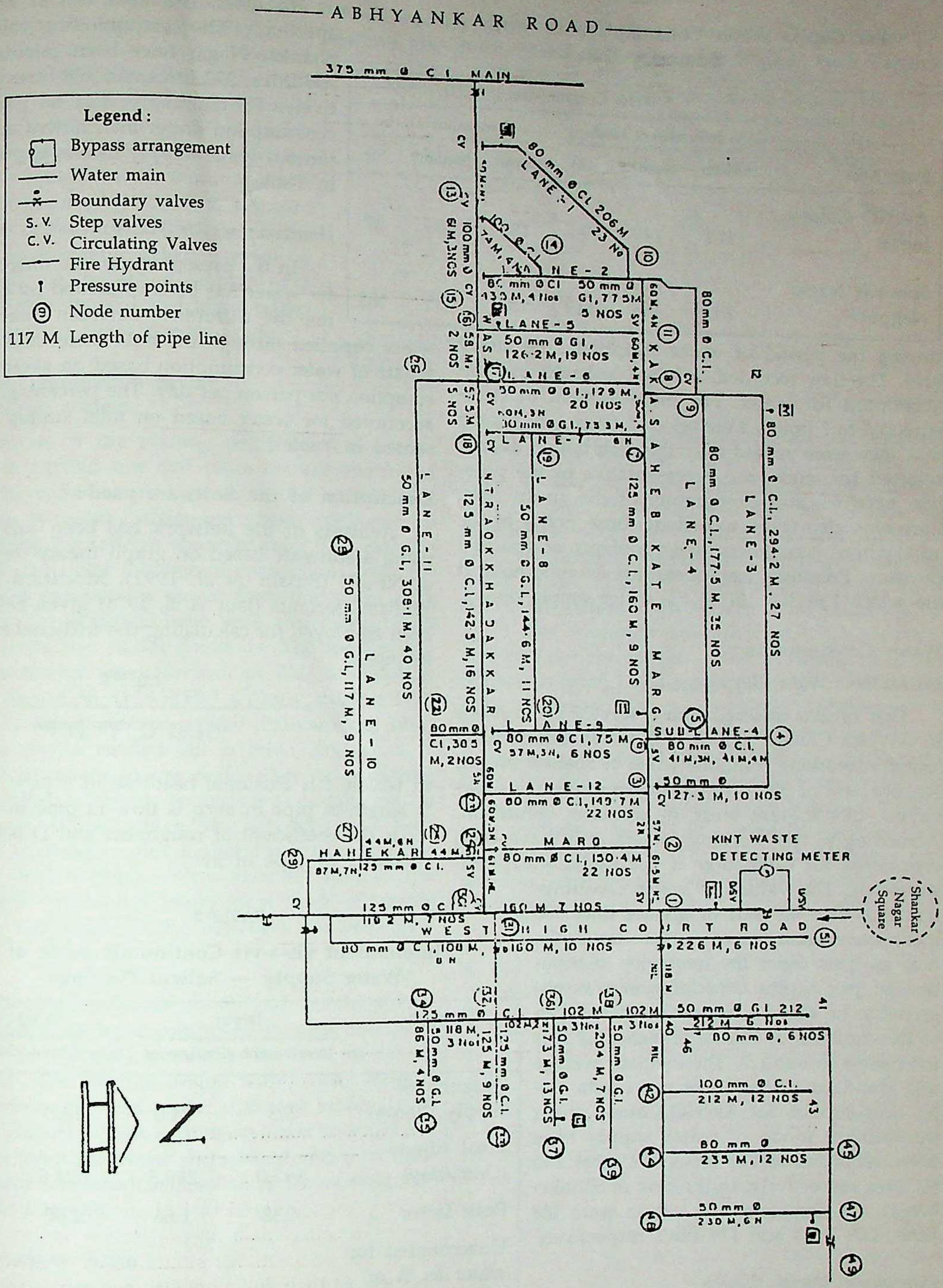
ABHYANKAR ROAD
375 mm Ø C.I. MAIN
Legend:
Bypass arrangement
Water main
Boundary valves
S.V. Step valves
C.V. Circulating Valves
Fire Hydrant
Pressure points
9 Node number
117 M Length of pipe line
80 mm Ø CI 206 M 23 No
LANE-1
LANE-2
LANE-3
LANE-4
LANE-5
LANE-6
LANE-7
LANE-8
LANE-9
LANE-10
LANE-11
LANE-12
SUB LANE-4
50 mm Ø G.I. 126.2 M, 19 NOS
30 mm Ø G.I., 129 M, 20 NOS
80 mm Ø C.I., 294.2 M, 27 NOS
80 mm Ø C.I., 177.5 M, 25 NOS
125 mm Ø C.I., 160 M, 9 NOS
50 mm Ø G.I., 144.6 M, 11 NOS
125 mm Ø C.I., 142.5 M, 16 NOS
50 mm Ø G.I., 308.1 M, 40 NOS
50 mm Ø G.I., 117 M, 9 NOS
80 mm Ø CI, 75 M
80 mm Ø C.I., 149.7 M, 22 NOS
80 mm Ø C.I., 150.4 M, 22 NOS
50 mm Ø 127.3 M, 10 NOS
KASAHEB KATE MARG
NTRAOKKHADAKKAR
MARG
HAHEKAR
WEST HIGH COURT ROAD
KINT WASTE DETECTING METER
Shankar Nagar Square
80 mm Ø C.I., 108 M
160 M, 10 NOS
226 M, 6 NOS
50 mm Ø GI 212
100 mm Ø C.I. 212 M, 12 NOS
80 mm Ø 235 M, 12 NOS
50 mm Ø 230 M, 6 N
Z

Fig. 2

Details of distribution network in study area : Shankar Nagar, Nagpur

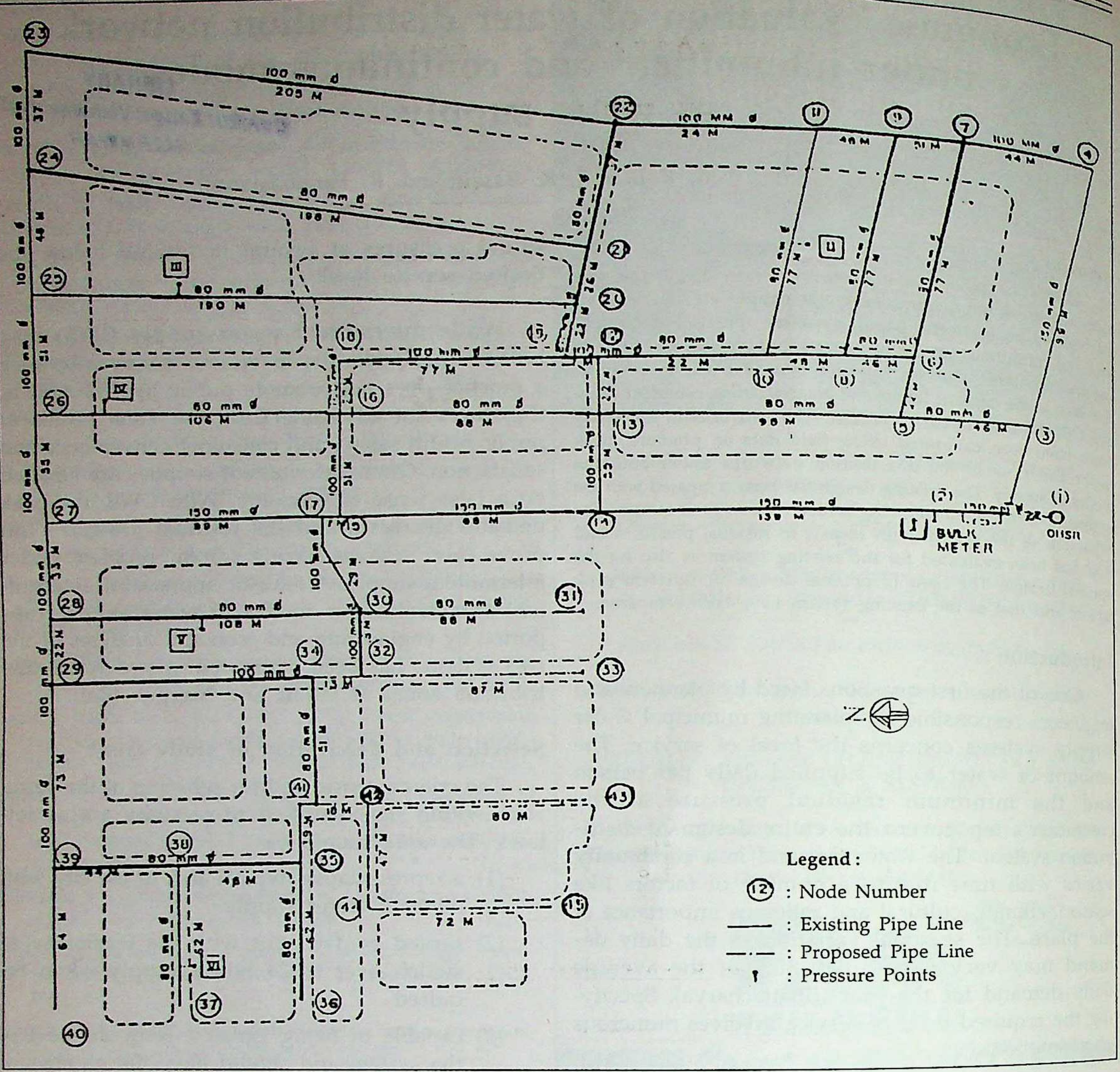

Fig. 1

Details of distribution network in study area : AWHO Colony, Jaipur

and half hours in the morning (5 a.m. to 7.30 a.m.) and evening (5 p.m. to 7.30 p.m.). The network consists of 51 pipes ranging from 80 mm to 150 mm in diameter and 39 nodes including source node (number 1). With the increase in demand, after construction of houses on vacant plots, seven additional pipes are to be laid as shown in dotted lines in Fig. 1. It is presumed that the main feeder does not supply water to any other area.

The distribution network of Shankar Nagar, Nagpur which represents a typical residential area, is depicted in Fig. 2. The area developed in early sixties has 380 plots and a population of about 3340. The area normally gets IWS for a long duration of sixteen hours from 5 p.m. to 9 a.m. The network consists of 70 pipes ranging from 50 mm to 200 mm in diameter and 52 nodes including source node. The area is mainly fed from ground level reservoir (GLR) at Seminary Hills located 7 km away and partly from GLR at Ramnagar, 1.5 km away. Field survey was undertaken in both the study areas in order to collect data on population served, number of house connections, status of water meters with respect to their functionality, per capita water consumption and consumer opinion on degree of service. A bulk meter was installed in the feeder main in order to measure the flow and its variation

Economic evaluation of water distribution network under intermittent and continuous modes of water supply

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Indrani Gupta, P. S. Kelkar, J. K. Bassin and R. Paramasivam*

Abstract :

In most of the developing countries water distribution systems designed for continuous water supply are operated on intermittent mode. In this paper, a realistic appraisal of intermittent and continuous modes of water supply including engineering and economic analyses has been made for two study areas, one each in the cities of Jaipur and Nagpur, using computer package OPTDIS developed by NEERI. The networks in the study areas have been calibrated using field data on pressure, peak factor and flow in the distribution networks under both the modes of supply. The existing design has been compared with the optimal design for functionality under various peak factors. The behaviour of the system with respect to residual pressures and flow has been evaluated for the existing system as also for the optimal design. The costs of optimal design for different peak factors and that of the existing system have been compared.

Introduction :

One of the first questions faced by planners and engineers responsible for planning municipal water supply systems concerns the level of service. The amount of water to be supplied daily per person and the minimum residual pressure at the consumer's tap govern the entire design of distribution system. The water demand in a community varies with time due to a number of factors like season, climate, cultural and religious importance of the place. The seasonal variation in the daily demand may vary from 10 to 30% of the average daily demand for the year (Bhattacharya). Specifying the required level of service involves numerous considerations.

Urban water distribution systems are generally designed for continuous mode of operation. The residual pressure under peak demand depends upon a number of factors viz. (i) layout of the network, (ii) population served by the network, and (iii) the carrying capacity of the system. Increasing population density in cities and towns has resulted in severe strain on the distribution systems laid a few decades back. Non-availability of adequate quantity of water is also a major constraint in providing continuous water supply (CWS). Thus, by and large, the distribution systems designed for continuous water supply are operated on intermittent mode in practice with the result that the residual pressures at several nodes fall below the desired service level.

While intermittent water supply (IWS) may become inevitable due to various constraints, such a practice does not promote public hygiene and is, therefore, not advisable from the view points of public health safety, and consumer convenience and satisfaction. Often, intermittent supplies are justified on a false sense of economy. With CWS, the peak demand decreases and the residual pressures improve even in areas having chronic problem under intermittent supply. A realistic appraisal of intermittent and continuous modes of water supply supported by engineering and economic analyses of the two systems has been attempted in two water distribution zones at Jaipur and Nagpur (Ref. 7)

Selection and description of study area :

The criteria considered for selection of the study zone within the identified project city are as follows. The area should be

(1) a representative/typical area of the city with metered water supply
(2) served by IWS but with the feasibility to switch over to 24 hours supply when required
(3) capable of being isolated from the rest of the system and should have the number of house connections between 200 and 600 or population between 1200 and 3600.

The layout plan of the study area at AWHO Colony, Jaipur is depicted in Fig. 1. All houses are provided with overhead tanks connected to the distribution system. Further, only one tap in the kitchen receives water directly from the municipal supply while the rest of the taps in the house and garden are supplied through the overhead tank. The colony receives its water supply from the overhead service reservoir (OHSR) constructed 500 m away from the colony. The study area presently consists of 208 households, all of which are provided with metered supply and after full development of the area, the number of water connections will increase to 306. Usual water supply durations are for two

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References :

Bhave, P. R. (1978). 'Noncomputer optimisation of single source networks'. *J. Envir. Engg. Div.*, ASCE, 104(4), 799-814.

Bhave, P. R. (1979). 'Selecting pipe sizes in network optimisation by LP'. *J. Hydr. Div.*, ASCE, 105(8), 1019-1025.

Bhave, P. R. (1982). 'Optimal design of dead-end water distribution systems for variable demand.' *J. IWWA*, 14(1), 3-7.

Bhave, P. R. (1985). 'Optimal expansion of water distribution systems.' *J. Envir. Engg.*, ASCE, 11(2), 177-195.

Brown, K. M., (1969). 'A quadratically convergent Newton-like method based upon Gaussian elimination,' *J. Numerical Analysis*, SIAM, Vol-6, No. 4, 560-569.

Chiplunkar, A. V., and Khanna, P. (1983). 'Optimal design of branched water supply networks.' *J. Envir. Engg.*, ASCE, 109(3), 604-618.

Cowan, J. (1971). 'Checking trunk main design for cost effectiveness.' *Water and Water Engg.*, 75, No. 908, 385-390.

Deb, A. K. (1973). 'Least cost design of water main in series.' *J. Envir. Engg. Div.*, ASCE, 99(3), 405-409.

Deb, A. K. (1974). 'Least cost design of branched pipe network systems.' *J. Envir. Engg. Div.*, ASCE, 100(4), 821-835.

Fujiwara, O, and Dey, D. (1988). 'Method of optimal design of branched network on flat terrain.' *J. Envir. Engg.*, ASCE, 114(6), 1464-1475.

Gupta, I. (1969). 'Linear programming analysis of a water supply system.' *Trans. Am. Inst. of Industrial Engrs.*, 1(1), 56-61.

Gupta, I., Hasan, M. Z., and Cook, J. (1972). 'Linear programming analysis of a water supply system with multiple supply points.' *Trans. Am. Inst. of Industrial Engrs.*, 4(3), 200-204.

Johnson, S., Gupta, R., and Bhave, P. R. (1995). Discussion of 'Design of branched-water-supply network on uneven terrain.' by Brian Young, *J. Envir. Engg.*, ASCE, (Accepted for publication.)

Kareliotis, S. J. (1984). 'Optimisation of tree-like water-supply system.' *J. of Hydrology*, 68, 419-429.

Karmeli, D., Gadish, Y., and Meyers, S. (1968). 'Design of optimal water distribution networks.' *J. Pipeline Div.*, ASCE, 94(1), 1-10.

Liang, T. (1971). 'Design of conduit system by dynamic programming.' *J. Hydr. Engg.*, ASCE, 97(3), 383-393.

Ormsbee, L., and Kessler, A. (1990). 'Optimal upgrading of hydraulic-network reliability.' *J. Water Resour. Plng. and Mgmt.*, ASCE, 116(6), 784-802.

Sonak V. V. and Bhave P. R. (1993). 'Global optimum tree solution for single-source looped water distribution networks subjected to a single loading pattern,' *Water Resour. Res.*, 29(7), 2437-2443.

Swamee, P. K., Kumar, V., and Khanna, P. (1973). 'Optimisation of dead end water distribution networks.' *J. Envir. Engg.*, ASCE, 99(2), 123-134.

Yang, K. P., Liang, T., and Wu, I. P. (1975). 'Design of conduit system with diverging branches.' *J. Hydr. Div.*, ASCE, 101(1), 167-188.

Young, B. (1994). 'Design of branched-water-supply network on uneven terrain', *J. Envir. Engg.*, ASCE, 120(4), 974-980.

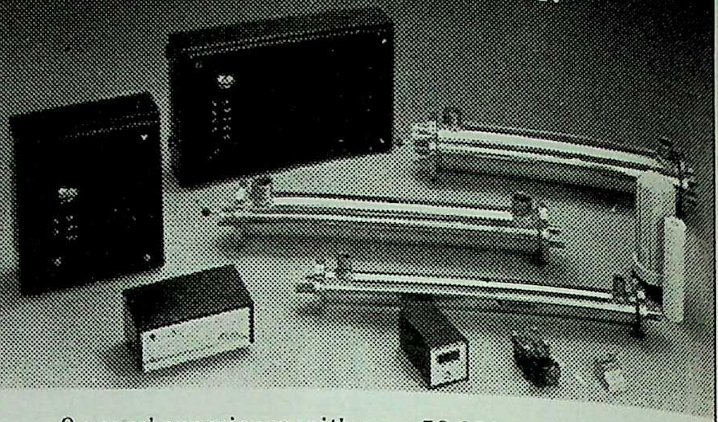

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TABLE 1

Comparison of different algorithms

	Continuous-diameter approach				Discrete-diameter approach	
	Deb's method	Bhave's method	Lagrangian multiplier technique	Chiplunkar and Khanna's approximate method	LP	DP
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Design variables	Diameter Source head	Diameter Source head	Diameter Source head	Diameter Source head	Pipe length Source head	Diameter Source head
2. Cost function	Can include cost of links, pumps, energy and service reservoirs				Cost of links and energy; other costs can be considered if they are linear function of variables	All costs associated with WDN
3. Computational requirements using hand calculator	Increases with increase in number of links common to more than one branch	Increases with increase in number of intermediate demand nodes	Increases with number of critical nodes	Least computational efforts	Difficult to solve even moderate-size practical networks	
4. Suitability with computers	Suitable for computers. Since Bhave's method tackles the problem in pieces computer storage requirement is less				Can be conveniently used with computers	Requires large memory and execution time
5. Application to						
(a) Multi-source WDNs	No	Yes	No	No	Yes	No
(b) Multiple loadings	No	No	Yes*	No	Yes	No
(c) Uneven terrain	No	Yes	Yes*	Yes*	Yes	Yes
(d) Expansion	No	Yes	Yes*	No	Yes	No
6. Limitations	Considers diameter as continuous variable, thus noncommercial pipe sizes must be converted to commercial sizes. This increases cost.				Cannot be conveniently used where computers are not available	
	Takes m (Eq.6) and K values same for all pipe sizes		Takes m (Eq. 6) and K values same for all pipe sizes			Selects all links of single size during optimization and therefore gives an inferior solution.

* Complexity increases due to the increase of constraints, hence the problem becomes difficult to tackle.

3.2.2 *Dynamic Programming* :

The dynamic programming (DP) technique is a systematic way of selecting an optimum program from a series of events and does not involve any mathematics. Liang (1971) developed a DP-based optimisation algorithm for design of a serial WDN. Each pipe segment of a network was treated as a DP stage. The total heads at the inlet and outlet of each segment of pipe were the input and output state variables of each stage. The pipe diameter was considered as a decision variable of each stage. The sum of pipe material cost, power cost, and wasted water cost was used as a criterion for measuring system effectiveness. This method was extended to branched WDNs by Yang, *et al.* (1975).

Kareliotis (1984) used LP and DP techniques together to optimise a single-source branched WDN. The system was divided into DP stages and the pressure head was treated as a decision variable at each stage. The separation into stages was such that optimum return determined by LP could be obtained for a particular flow pattern.

4. Illustrative example :

The different optimisation techniques described herein are applied to a branched WDN shown in Fig. 1.

The network consists of one source (labelled 1) and seven demand nodes (labelled 2, ...8). The available head at the source is 100 m, while the minimum required head at each demand node is 90m. Nodal demands are also shown in Fig. 1. The network has seven links labelled 1,...,7 and their lengths are as shown in parentheses in Fig. 1. The commercially available pipe sizes and their unit costs, given in parentheses, are: 100 mm (Rs.334); 125 (390); 150 (469); 200 (668); 250 (892); 300 (1138); and 350 (1413). The cost-diameter relationship as obtained by regression analysis is $c = 1.35\ D^{1.179}$, in which c is unit cost and D is pipe diameter in millimeters. Hazen-Williams head loss equation is used with $K = 4.333 \times 10^8$ for all pipes.

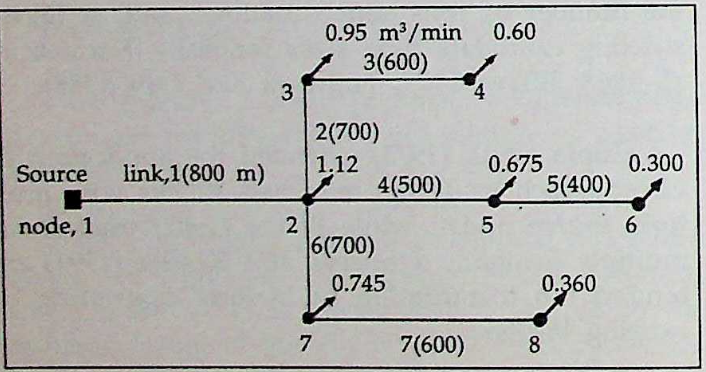

Fig. 1
Branched Network for illustrative example :

All the continuous-diameter approaches (viz. Deb's method, Bhave's method, and Lagrangian multiplier technique) provided identical solution. The network cost was obtained as Rs.28,51,210. This solution is global optimum for continuous pipe sizes. When noncommercial sizes were changed to commercial sizes the cost of the network increased slightly to Rs.28,90,802.

The network cost as obtained by Chiplunkar and Khanna's approximate method (1983) was Rs.29,47,292. When noncommercial sizes were changed to commercial sizes by rounding the size of first link to nearest available higher size and sizes of subsequent links to nearest higher or lower size by taking the advantage of additional available head the network cost decreased slightly to Rs.29,32,021.

The discrete diameter approaches based on: (1) LP provided the network cost as Rs.28,72,805; and (2) DP provided the network cost as Rs.29,71,500.

The DP provided the costliest solution as all the links were of single size and total available heads along the paths were not fully utilised. Chiplunkar and Khanna's approximate method utilised the available head completely; thus the obtained solution was cheaper than that obtained by DP but was costlier than the solutions obtained by other continuous-diameter approaches. The discrete-diameter approach based on LP provided the global optimum solution.

5. Comparison of optimisation algorithms :

On the basis of solution of a large number of networks, optimisation algorithms were compared. Comparison of these algorithms is given in Table 1.

6. Summary and conclusions :

Various optimisation algorithms for design of branched WDNs are briefly reviewed and compared. The continuous-diameter approach of Bhave (1978) is general, takes into consideration the head requirement at intermediate nodes also. Since it tackles the optimisation problem in pieces it is convenient for hand calculation. The discrete-diameter approach based on linear programming provides global minimum solution for branched WDNs, however the approach needs a computer. Since computers are now commonly available, the LP approach can be easily used to obtain the global optimum solution for branched WDNs.

head) and equating the expressions thus obtained to zero. The solution of resulting nonlinear equations provides minimum cost design if the Lagrangian multipliers are positive.

Swamee, *et al.* (1973) applied this technique to optimise serial WDNs considering continuous as well as discrete withdrawals. They derived an equation for optimal diameter of links as

$$D_i = Q_1^{p/(m+r)} \text{ [M.F.]} \quad \text{......} \quad (10)$$

where Q_1 is discharge in the first link of the serial network; and M.F. is a multiplying factor given by

$$\text{M.F.} = \left[\frac{K S L_i Q_i^{mp/(m+r)}}{(H_o - H_n)} \right]^{1/r} \quad \text{......} \quad (11)$$

Similarly, expression for optimum pumping head was derived by differentiating Lagrangian function with respect to source head.

Chiplunkar and Khanna (1983) applied LMT to design branching WDNs. Lagrangian function was differentiated with respect to design variables and a set of nonlinear equations was obtained. These nonlinear equations were solved by Brown's algorithm (Brown 1969). Young (1994) proposed Newton-Raphson method for their solution in the optimal design of a WDN on an uneven terrain. Johnson *et al.* (1995) discussed the limitations of this approach.

Considering the problems in solving nonlinear equations, Chiplunkar and Khanna (1983) suggested an approximate method in which M.F. was calculated for each branch considering it to be independent of each other. For sections occurring in only one branch, M.F. was taken as that for the branch in which it occurred. However, in case of sections common to more than one branch, the M.F. values of all the branches in which the section occurred were calculated and the maximum value of M.F. was selected. The optimal diameter of each section was then computed from Eq. 10. In case of direct pumping systems or combined pumping and gravity systems, optimum pumping head for each branch was computed and maximum pumping head was reckoned as the system head. Diameter of each section was then estimated by Eq. 10 and subsequent rounding off to available commercial size was carried out.

3.2 *Discrete-diameter Approach :*

In this approach the link diameter is considered as a discrete variable; thus, the final solution obtained by these models gives diameters which are commercially available. Methods which come under this category are based on linear programming and dynamic programming.

3.2.1 *Linear Programming Approach :*

The linear programming (LP) approach is based on the concept that the resistance of a pipe and its cost are linear functions of its length. Therefore, if one selects pipe length as a decision variable, the problem can be formulated as one in LP.

Karmeli, *et al.* (1968), Gupta (1969), suggested the application of LP-based models for the design of branched WDNs. The mathematical model can be written as

$$\text{Minimise } C_T = \sum_I \sum_J c_{ij} L_{ij} + K_8 (H_o) \quad \text{......} \quad (12)$$

subjected to

$$\sum_J L_{ij} = L_i \text{ for } i = 1 \ldots I \quad \text{......} \quad (13)$$

$$\sum_I \sum_J S_{ij} L_{ij} \le H_o - H_n \text{ for all paths} \quad \text{......} \quad (14)$$

$$L_{ij} \ge 0 \quad \text{......} \quad (15)$$

Where, c_{ij} is unit cost of ith pipe of jth diameter; L_{ij} = length of ith pipe with jth diameter; S_{ij} = head loss per unit length for jth diameter pipe of ith link; J is the number of pipe diameters available for ith pipe; and K_8 is a constant which considers all the head dependent cost function of Eq. 1.

To obtain the global optimum solution, each link must be free to choose its component pipe sizes from the whole lot of available pipe sizes. When this is permitted the LP model becomes too big to tackle. Hence it is necessary to restrict the size of the LP model which can be done by (1) Reducing the number of constraint equations; and/or (2) restricting candidate pipe sizes for links (Karmeli *et al.* 1968; Bhave 1979, Fujiwara and Dey 1988).

Gupta, et at. (1972) extended the application of LP approach to design branched WDNs with multiple source nodes, while Bhave (1982) used it for multiple demands. Ormsbee and Kessler (1991) extended the formulation to include upgrading of existing WDNs.

Thus, for a single-source network

$$\sum KL_iQ_i^pD_i^{-r} \le H_o - H_n, \text{ for all paths T} \ldots\ldots\ldots (4)$$

$i \in$ path T

2.2.2 *Availability of diameter :*

Selected pipe diameters for different links must be of commercial available size. Thus,

$$D_i \in \text{Commercially available diameters} \ldots\ldots\ldots\ldots (5)$$

3. **Optimisation algorithms :**

The algorithms for the optimal design of WDNs can be classified in two categories : (1) Continuous-diameter approach treating the link diameter as a continuous variable; and (2) discrete-diameter approach treating the link diameter as a discrete variable.

3.1 *Continuous-diameter Approach :*

In this approach, the diameter availability constraints (Eq.5) are initially suppressed and the link diameter is treated as a continuous variable. The unit cost of a link, c, is represented as a function of diameter i.e.,

$$c = K_1D^m \ldots\ldots\ldots (6)$$

where, K_1 and m are constants and obtained by regression analysis.

The non-commercial pipe sizes of the optimal solution are converted to commercial sizes with slight increase in cost.

3.1.1 *Methods based on Cost-Headloss Ratio criterion :*

For minimum cost of a serial network, Cowan (1971) showed that,

$$\frac{\text{Headloss in link i}}{\text{Total headloss}} = \frac{\text{Cost of link i}}{\text{Total cost}} \ldots\ldots\ldots (7)$$

Using Eq.(7), Cowan proposed a trial-and-error procedure for minimum cost design of a serial network.

Deb (1973) formulated a systematic procedure based on Eq.(7) for designing a serial network. Later, Deb (1974) extended this technique to the optimal design of branched WDNs. This procedure involved solving all the single branches in the network containing links in series only. This was followed by combining two single branches at a time. This linking of pair of single branches (or modified combined pair) was continued till the whole network was covered. Deb (1974) also developed approximate direct equation to obtain optimum source head for direct pumping or combined pumping and gravity system. However, the method is applicable only when the total allowable headloss is same for all branches.

Bhave (1978), developed a general method to obtain optimal solution using the cost-headloss ratio criterion. He showed that for a minimum cost WDN

$$\Sigma(mC/h)_{ij} = \Sigma(mC/h)_{jk}, \quad \text{for a junction node j} \ldots\ldots\ldots (8)$$

in which ij and jk represent supply and distribution links incident at junction j, respectively.

To design a WDN satisfying this criterion, Bhave (1978) proposed an iterative procedure in which heads at demand nodes were assumed initially using critical path concept (Bhave 1978, 1979) for a particular value of source head, and successively corrected using

$$\Delta H_j = \frac{-\Sigma(mC/h)_{ij} + \Sigma(mC/h)_{jk}}{\Sigma(mC/h^2)_{ij} + \Sigma(mC/h^2)_{jk}} \ldots\ldots\ldots (9)$$

in which ΔH_j is correction in head value at a node j.

The correction at a node for any iteration is restricted to a value such that it satisfies the head constraint (Eq.3). The iterative procedure is terminated when (a) all ΔH_j values become insignificant; or (b) successive decrease in C_T becomes negligible. The cost-headloss ratio criterion is also extended to expand existing WDNs, (Bhave 1985). The approach can also be extended to consider pumped as well as multiple-source networks.

3.1.2 *Lagrangian multiplier technique :*

In Lagrangian multiplier technique (LMT), the constraints are combined with the objective function through Lagrangian multipliers to obtain a Lagrangian function. Thus, a constrained optimisation problem is converted to an unconstrained one. The optimal solution is achieved by taking the first partial derivative of the Lagrangian function with respect to decision variables (diameters and source

Optimisation algorithms for design of branched water distribution networks

Arun Kansal*, **Rajesh Gupta**** and **Pramod R. Bhave*****

Abstract :

Optimisation of water distribution networks (WDNs) has attracted the attention of researchers in the past three decades and several algorithms are proposed. The available algorithms for the design of branched WDNs are reviewed, and compared herein. These algorithms are also applied to design a branched WDN.

1. Introduction :

Water distribution networks for rural, agricultural and industrial supplies are generally branched for economic reasons. Sometimes, even a looped WDN is designed by converting it to a branched network consisting of primary links and selecting the secondary links either of some specified diameter or carrying some specified discharge (Bhave 1978, Sonak and Bhave 1993). Since a WDN is the costliest part in most of the water supply schemes, it is desirable to optimise the WDN for minimum cost. Several researchers have dealt with optimisation of branched WDNs. Their work has been reviewed and compared herein.

2. Structure of optimisation algorithm :

The layout of a WDN is normally decided by the street pattern and several topological factors such as hills, depressions, rivers etc. Discharges in various links of a branched WDN can also be determined from known nodal consumptions. Therefore, the unknown parameters in the design are the diameters of different links and the supply heads at different sources.

2.1 *Objective Function :*

Objective function for a WDN includes capital cost of network, C_{net}; capital cost of pumps, C_p; capital cost of service reservoir, C_r; capitalised maintenance cost of network, C_{cmn} (a function of diameter of different links); capitalised energy cost for pumping, C_{cep}; and capitalised maintenance and repair cost of pumps, C_{cmp} (a function of source head).

Therefore objective function is to minimise the total cost, C_T

$$\text{Minimise } C_T = C_{net} + \sum_P C_p + \sum_R C_r + C_{cmn} + \sum_P C_{cep} + \sum_R C_{cmp} \quad \text{(1a)}$$

$$\text{or, } C_T = \sum_I C_i + \sum_P K_2[Q_{net}(H_o - H_n)]^{m1} + \sum_R (K_3 H_o + K_4)V^{m2} + K_5(C_{net}) + \sum_P K_6 Q_{net} H_o + \sum_P K_7(H_o) \quad \text{(1b)}$$

in which I, P and R are total number of pipes, pumps and reservoirs respectively; C_i is cost of a pipe i; Q_{net} is the total discharge; H_o and H_n are heads at source and end nodes, respectively; V is the volume of service reservoir; K_2, ..., K_7 are constants and m_1 and m_2 are exponents.

It can be seen from the objective function that total cost of a WDN depends on diameters of different links and supply heads at different sources. If supply heads increase, the costs of pump, power and service reservoir increase but network cost decreases due to increase in available friction losses. Thus, the total cost function is convex with respect to source heads.

2.2 *Constraint Equations :*

The general form of frictional headloss equation for a link is :

$$h = K\,L\,Q^p\,D^{-r} \quad \text{(2)}$$

where, h = headloss through a link of length L and diameter D while carrying a discharge Q; p and r = exponents of discharge and diameter, respectively; K = constant that depends on diameter and material of links and units of other terms.

2.2.1 *Head constraints :*

Available head, H_j^{avl}, at any node j should be greater than or equal to minimum required head, H_j^{min}, i.e.

$$H_j^{avl} \geq H_j^{min} \quad \text{(3)}$$

---

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Rachform, T. M., *'Time-capacity Expansion of Waste Treatment Systems'*, Proc. of A.S.C.E., Sanitary Division, SA 6, Dec., 1969, P. 1063.

Shoup, T. E., *'Applied Numerical Methods for the Microcomputer'*, Prentice Hall, Inc., 1984, P. 21.

Yaffey, M., *'Personal Notes'*, D.P.P.C., University of Bradford.

Appendix :

```
/*........
Program alfa.c
Set Up Model to Show Optimal
Interval Between Successive Expansions
——————————*/

# include <conio.h>
# include <stdio.h>
# include <math.h>

# define ONE96 196
# define TWO24 224

void main()

{

int i;

float tol,atol,nt,dt,r,r1,t,t1,alfa,x;

float amin,amax,ai,rmin,rmax,ri,tguess,xmax;

FILE *fw;

fw = fopen (“alfa.out”, “w”);

clrscr();

gotoxy(35,1); printf(“DATA ENTRY/n”);

gotoxy(8,3);printf(“Min. Scale Factor(%c”,
TWO24);printf(“):”);

scanf(“%f”,&amin);

gotoxy(40,3); printf(“Min.Discount
Rate(%):”);scanf(“%f”,&rmin);

gotoxy(8,5); printf(“Max.Scale Factor
:”);scanf(“%f”,&amax);

gotoxy (40,5); printf(“Max.Discount Rate(%) :”);
scanf(“%f”,&rmax);

gotoxy (8,7); printf(“Increment :”);scanf(“%f”,&ai);

gotoxy(40,7); printf(“Increment(%)
:”);scanf(“%f”,&ri);

gotoxy(8,9); printf(“Initial guess of t
:”);scanf(“%f”,&tguess);

gotoxy(40,9); printf(“Max.Iterations
:”);scanf(“%f”,&xmax);

gotoxy(5,17); printf(“Press Enter
Key...”);getch();clrscr();

alfa = amin;

r = rmin;

t = tguess;

atol = 0;

tol = .000001;

x = 1;

gotoxy(22,1);fprintf(fw,“OPTIMAL VALUES OF
PERIODS OF SUCCESSIVE”);

gotoxy(22,2);fprintf(fw,”        EXPANSIONS OF A
PROJECT\n”);

fprintf(fw, “r= ”);

for(i=(int) rmin;i<=(int) rmax;i++)

fprintf(fw,”   %2d”,i);

fprintf(fw,”\n”);

fprintf(fw, “%c”, TWO24);

fprintf(fw,”=\n”);

do

{

    fprintf(fw,” %3.1f”,alfa);
    do
    {
        r1=r/100;
        do
        {
            nt=alfa*exp(rl*t)-rl*t-alfa;
            dt=alfa*rl*exp(rl*t)-rl;
            tl=t-nt/dt;
            atol=fabs(t1-t);
            if(atol > tol)
            t=tl;
            x++;
        } while (x < = xmax);
        fprintf(fw,”   %3d”, (int) tl);
        r=r+ri;
        x=1;
        t=tguess;
        atol=0;
    } while(r < = rmax);
    alfa=alfa+ai;
    x=1;
    t=tguess;
    atol=0;
    r=rmin;
    fprintf(fw,”\n”);
  } while (alfa < = (amax+ai));
  getch();
}
```

* * *

TABLE 6

Present worth of the capacity proposed and the capacity computed by CPHEEO norms

Design stage (Years)	Present worth of the proposed capacities (Rs. Lakhs)	Present worth of the capacities computed by CPHEEO norms (Rs. Lakhs)	Additional cost (col 3-2) (Rs. Lakhs)
1	2	3	4
0	1629.64	3107.25	1477.61
5	2108.49	3107.25	998.76
10	2380.20	3107.25	727.06
15	2534.37	3107.25	572.88
20	2621.85	3470.40	848.55
25	2671.49	3470.40	798.91
30	2699.66	3470.40	770.74

norms. Instead of using the CPHEEO's large design stages of 15 years (immediate stage) and 30 years (ultimate stage), the small design stages preferably 5 to 10 years in the expansion scheduling of the existing plant are suggested here.

(3) The optimum expansion periods are found sensitive to both the scale factor and opportunity costs (rate of discount). Keeping one of the parameters (α or r) constant and increasing the other, the optimum values of expansion period decline.

(4) Based on the model, capacity expansion of water treatment plant of Amravati water supply scheme is discussed. It is observed that there is a need to augment the water treatment plant after every 5 years with successive plant capacity of 15 mld. The present capacity of 95 mld is very near to the analysis which validates the model also.

(5) Some deviations in the augmentation schedule, so worked out, may be necessary in view of the typical conditions such as availability of space, suitability of topography and geography of the area, and the delay in construction period. Considering these constraints, the capacity of the water treatment plant of Amravati city has been finally adopted as 95 mld eventhough the capacity of 90 mld was worked out as per the model.

(6) The analysis very clearly shows that the augmentation period becomes smaller and smaller at higher discount rates, virtually indicating a continuous augmentation schedule which may not be practically feasible. In such situations reasonably larger expansion periods can only be considered if the central/state government share a part of the cost of the project in the form of grant-in-aid.

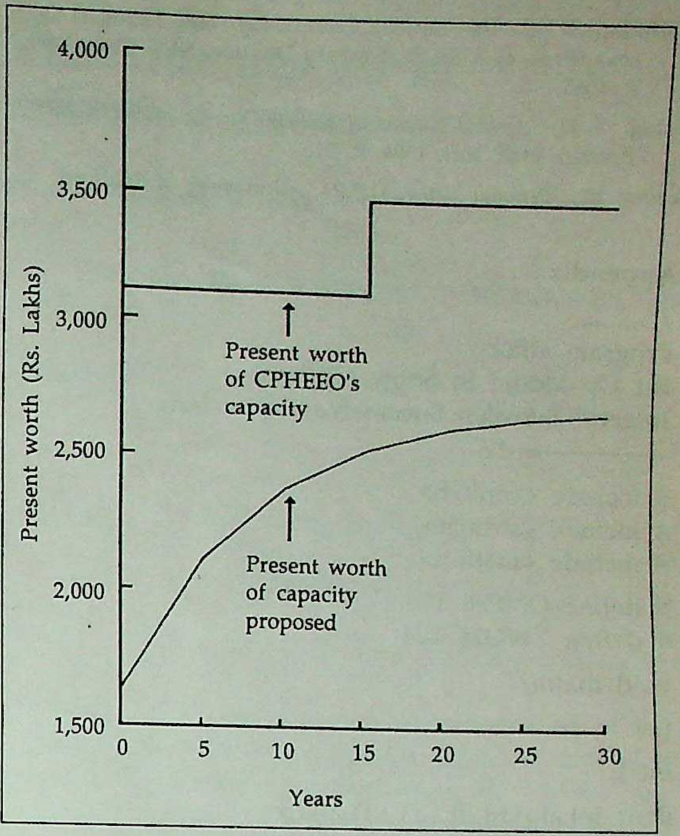

Fig. 3
Present worth of the proposed capacity and capacity by CPHEEO manual

6. Acknowledgement :

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7. References :

Chiange, C. C., *'Fundamental Methods of Mathematical Economics'*, McGraw IIill Ltd., Second edition, P. 224.

Manne, A. S., *'Investments for Capacity Expansion'*, George Allen and Unwin Ltd., 1967, P. 34.

Mujumdar, J., *'Personal Notes'*, D.P.P.C., University of Bradford, 1992.

Pratten C. F., *'Economies of Scale in Manufacturing Industry'*, Cambridge University Press, 1971, P. 7.

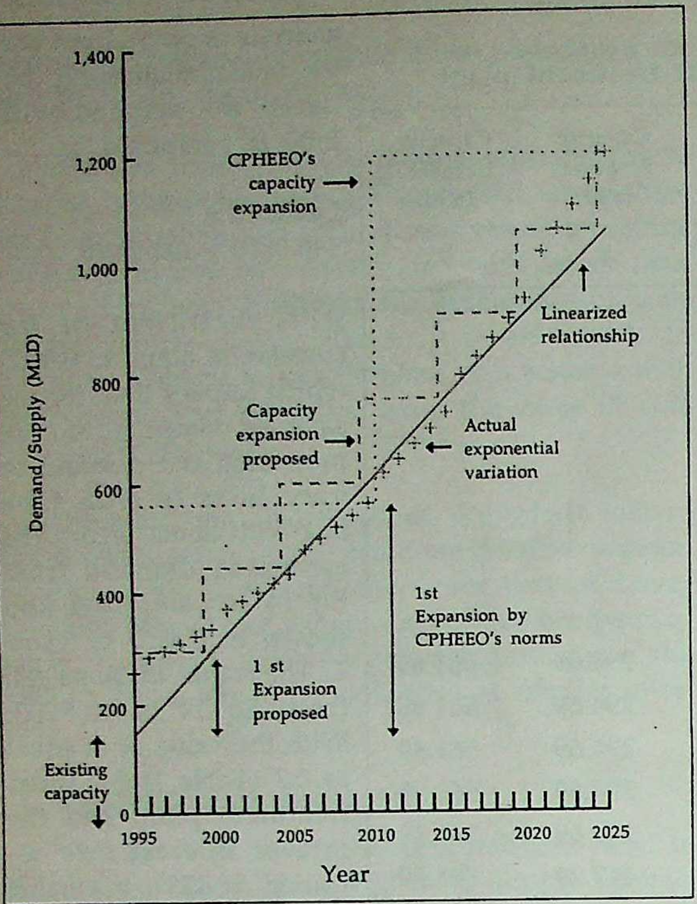

Fig. 2
Demand and required supply of Jaipur

capacity computed by CPHEEO norms are worked out. The future costs of the additional capacities are computed by multiplying the value of 'cost per MLD' with that of the value of additional capacity. A figure of Rs. 5.53 Lakhs/MLD has been used in the present analysis. The present worth values are then computed by discounting these future costs with the discounting rate(r) of 12% as follows:

$$\text{Present worth} = \text{Future cost} \times \left[\frac{1}{(1+r)^n}\right] \quad \text{......... (15)}$$

where: n = number of years

The present worth or the capitalized cost is computed by adding the present worth values of the additional capacities to the cost of the existing capacity (Table 6). The graph, comparing these values, is shown in Fig. 3.

It is evident from Table 6 and Fig. 3 that the present worth of capacities computed by adopting the CPHEEO norms are much more than those of proposed capacities computed by Manne's model. The difference is much more in the present stage (the year in which the additional capacity is installed). This means an increment in the additional capacity in successive expansions should be minimum and thus it should follow Manne's model based on the economies of scale factors.

5. Conclusions :

(1) Application of a well known economic model as suggested by Manne and Rachford, for selection of optimum capacity expansion and scheduling of water supply systems has been discussed in this paper. A computer program is prepared to readily give values of expansion periods for given values of economy scale factors and rate of interest.

TABLE 5

Comparison of present worth of additional installed capacities

Year	Projected Demand	Proposed Capacity			Capacity by CPHEEO's norms		
		Proposed Supply	Additional capacity required	Present worth of Additional capacity	Supply as per CPHEEO manual	Additional capacity required CPHEEO	Present worth of Additional capacity
	(mld)	(mld)	(mld)	(Rs. lakhs)	(mld)	(mld)	(Rs. lakhs)
1	2	3	4	5	6	7	8
1995	142.09	294.69	—	—	561.89	—	—
2000	294.69	447.29	152.60	478.84	561.89	0.00	0.00
2005	447.29	599.89	152.60	271.71	561.89	0.00	0.00
2010	599.89	752.50	152.60	154.17	561.89	0.00	0.00
2015	752.49	905.10	152.60	87.48	1195.35	633.46	363.15
2020	905.09	1057.70	152.60	49.64	1195.35	0.00	0.00
2025	1057.69	1210.30	152.60	28.17	1195.35	0.00	0.00

(2) Manne's model gives an effective tool to a decision maker as to when and by how much a scheme as a whole or a particular component of the system, is to be expanded optimally keeping in view the economies of scale. The illustrative example of Jaipur city clearly shows that the cost would be much more if the design stages are considered using CPHEEO's

TABLE 4

Demand projection and supply of Jaipur water treatment plant

Year	Population forecast	lpcd	Demand (mld)	Demand Estimated (mld)	Capacity Proposed (mld)	Capacity CPHEEO (mld)
1	3	5	6	7	8	9
1951	2,91,130	100	29.11			
1961	4,03,444	110	44.38			
1971	6,15,258	120	73.83			
1981	9,77,165	130	127.03			
1991	14,58,486	140	204.19			
1992	15,18,080	150	227.71			
1993	15,80,113	150	237.02			
1994	16,44,680	150	246.70			
1995	17,11,886	150	256.78	142.09	294.69	561.89
1996	17,81,838	160	285.09	172.61	294.69	561.89
1997	18,54,648	160	296.74	203.13	294.69	561.89
1998	19,30,433	160	308.87	233.65	294.69	561.89
1999	20,09,316	160	321.49	264.17	294.69	561.89
2000	20,91,421	160	334.63	294.69	447.29	561.89
2001	21,76,882	170	370.07	325.21	447.29	561.89
2002	22,65,835	170	385.19	355.73	447.29	561.89
2003	23,58,422	170	400.93	386.25	447.29	561.89
2004	24,54,793	170	417.31	416.77	447.29	561.89
2005	25,55,102	170	434.37	447.29	599.89	561.89
2006	26,59,510	180	478.71	477.81	599.89	561.89
2007	27,68,184	180	498.27	508.33	599.89	561.89
2008	28,81,299	180	518.63	538.85	599.89	561.89
2009	29,99,036	180	539.83	569.37	599.89	561.89
2010	31,21,584	180	561.89	599.89	752.50	561.89
2011	32,49,139	190	617.34	630.41	752.50	1195.35
2012	33,81,907	190	642.56	660.93	752.50	1195.35
2013	35,20,100	190	668.82	691.45	752.50	1195.35
2014	36,63,940	190	696.15	721.97	752.50	1195.35
2015	38,13,658	190	724.60	752.49	905.10	1195.35
2016	39,69,493	200	793.90	783.01	905.10	1195.35
2017	41,31,696	200	826.34	813.53	905.10	1195.35
2018	43,00,528	200	860.11	844.05	905.10	1195.35
2019	44,76,258	200	895.25	874.57	905.10	1195.35
2020	46,59,169	200	931.83	905.09	1057.70	1195.35
2021	48,49,554	210	1018.41	935.61	1057.70	1195.35
2022	50,47,718	210	1060.02	966.13	1057.70	1195.35
2023	52,53,981	210	1103.34	996.65	1057.70	1195.35
2024	54,68,671	210	1148.42	1027.17	1057.70	1195.35
2025	56,92,135	210	1195.35	1057.69	1210.30	1195.35

analysis is carried out and the linear relationship between the demand with time is computed as

Demand =
$140.0853 + 30.5203\,t$ ... (14)

with coefficient of the correlation equal to 0.9825 which implies that, for the sake of computation, we may treat the demand to vary linearly with time but with some error. The estimated demand from Eq 14 is computed and shown in Col. 7 of Table 4. The value of slope (D) from Eq 14 is 30.5203. With the value of α equal to 0.7 (Table 1) for water treatment plant and the rate of interest rate assumed at 12%, the value of optimal time (t) is picked up as 5 years from Table 2. Putting the value of D and t in Eq 2, the value of plant capacity (V) is computed as 152.6. This means that the initial installation in the base year of 1995 should be 294.69 = (142.09 + 152.6). The resulting values of the capacity to be installed are shown in Col. 8 of Table 4. In the last column of Table 4, the capacity to be provided as per norms of CPHEEO, is shown. Fig. 2 shows the graphs of projected demand (nonlinear), derived demand estimation (linear), capacity to be installed as per Manne's model, and the capacity to be provided as per CPHEEO norms.

In Table 5, present worth values of the capacity proposed using the Manne's model, and the period decreases with increase in the scale factor for any particular discount rate.

The variation of scale factors with optimum time of expansion (Table 2) shows that when there are large economies of scale (lower values of α), the values of expansion periods are much larger than those which have relatively less economies of scale (higher values of α). Hence, it is affordable to construct a single large size plant or a scheme with large intervals of expansion when the value of α is less and vice-versa.

Discount rate also plays an important role in the determination of the optimum plant expansion period. Table 2, would also infer that at lower discount rate, larger expansion periods are permissible. However, with larger discount rates the scheme/plant has to be expanded at smaller intervals.

4. Application of model :

Two practical examples are illustrated here. In the first example of Amravati water supply scheme, a case of the water demand varying linearly with time, and in the second example of Jaipur water supply scheme, a nonlinear variation of demand with time is studied.

4.1 *Amravati Water Treatment Plant :*

Application of the method is discussed here for the treatment plant of the Amravati water supply scheme in Maharashtra. Average yearly water demand (D) for Amravati city is observed as 3 MLD.

4.1.1 *Computation of Scale Factor :*

The construction cost data of conventional water treatment plants of capacities ranging from 5 MLD to 95 MLD, based on Schedule of Rates applicable for Amravati region, is shown in Table 3.

The nonlinear regressive analysis is used to find the relationship between cost and capacity of a plant. The best fit relationship is

$$\text{Cost} = 13.0675\ V^{0.746} \quad \text{......(13)}$$

Coefficient of correlation for Eq 13 is 0.9917 which is very close to one. Comparing Eq 1 with Eq 13, value of α is found to be 0.746 (say 0.7). Since, α is less than one, there is a scale of economy to some extent.

4.1.2 *Computation of Optimal Augmentation Capacity and Interval :*

From Table 2, for a scale factor (α) of 0.7 and an interest rate of 12%, the value of optimal period for successive expansion is 5 years. From Eq 2, using yearly demand, D = 3 MLD and expansion period of 5 years, the augmentation capacity works out to 15 mld. The water demand in 1993 was 75 mld. The old existing water treatment plant has a capacity of 25 mld. This plant is too old and will have to be abandoned shortly. Therefore, considering optimal expansion period of 5 years, it is necessary to satisfy a demand of 90 mld in the year 1998. However, from practical considerations a plant of 95 mld is constructed.

4.2 *Jaipur water treatment plant :*

Population and water demand of Jaipur city for the decades from 1951 through 1991 is shown in Table 4. Since the city is fast growing, population forecast is made using geometrical increase method and the census figures of the decade 1981 and 1991 are only considered for the computation. Generally the daily per capita share (LPCD) of water increases with rise in the population. This is necessary to account for the rise in various needs (such as industrial requirement etc.) of the fast growing city. Hence, the LPCD figure, is increased by 10 after every 5 years. This has resulted in the exponential variation of the water demand (Col. 6 of Table 4) with respect to time (Fig. 2). Here, the limitation of Manne's model is realized as it is based on the linear variation of the demand with time. To overcome this difficulty and for the sake of applicability of Manne's model, regression

TABLE 3

Capacity and construction cost data

SN	Capacity (MLD)	Cost (Rs. Lakhs)	SN	Capacity (MLD)	Cost (Rs. Lakhs)	SN	Capacity (MLD)	Cost (Rs. Lakhs)
1	5	55.0	7	35	175.1	13	65	300.5
2	10	70.6	8	40	196.0	14	70	321.4
3	15	91.5	9	45	216.9	15	75	342.2
4	20	112.4	10	50	237.8	16	80	363.1
5	25	133.3	11	55	258.7	17	85	384.0
6	30	154.2	12	60	279.6	18	90	404.9
						19	95	425.8

On solving Eq(8), Manne obtained

$$\alpha = \frac{rt}{(e^{rt} - 1)} \qquad \text{.............................. (9)}$$

Operating costs such as fuel, raw material and labour have been omitted from the cost function (Eq 7) by Manne, because operating costs are generally proportional to the output of each plant and are not generally associated with economies of scale. Since a linear demand is assumed over a time period, and the plant life has been assumed as infinite from the consideration of analytical convenience, it results in identical regeneration (zero excess capacity) points (Fig. 1).

3. Computation of successive expansion period :

Eq 9 is an implicit equation and requires many trials to get solution for computation of expansion period(t). Hence, the Newton-Raphson numerical method is used here for the solution. The method uses extrapolation based on a line that is tangent to the curve at a point (Shoup, 1984). The method is based on Tailor's expansion. A computer program is prepared in C language and is enclosed as Appendix. In Newton-Raphson method, initial guess value of optimum period(t) of expansion is required. With minimum value of α and minimum discount rate(r), the optimum value of expansion period is worked out as follows :

From Eq 9,

$$f(t) = \alpha e^{rt} - rt - \alpha \qquad \text{............................ (10)}$$

First derivative of f(t) in Eq 10 is given by,

$$f'(t) = \alpha r e^{rt} - r \qquad \text{.................................... (11)}$$

Putting values of f(t) and f′(t) in Tailor's equation of approximation, it becomes :

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$$T_1 = T - \frac{f(t)}{f'(t)} \qquad \text{............................ (12)}$$

where : T = the initial guess value, considered as 100, and

T_1 = the new value of expansion period.

The absolute value of difference of T_1 and T is checked for the lowest tolerance which is considered as 1×10^{-6} in the present work. If this difference is greater than the tolerance, value of T_1 is assigned to T and process is repeated till the difference becomes less than or equal to the tolerance limit.

3.1 *Results and Discussion :*

The values of scale factor (α) are selected from 0.1 to 0.9. Then values of optimum expansion periods are computed for commonly used interest rates adopted in the loan component of financial pattern of water supply systems. This range varies from 5% to 20% and is shown in Table 2.

For any particular scale factor, it may be seen from Table 2 that the values of optimum expansion period decline as the values of discount rates (the interest rate is also called discount rate when the future cost is discounted or capitalized) are increased. Similarly, values of optimum expansion

TABLE 2

Optimal values of periods (years) of successive expansions of a project

r(%) : α	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0.1	72	60	51	45	40	36	32	30	27	25	24	22	21	20	19	18
0.2	53	44	38	33	29	26	24	22	20	19	17	16	15	14	14	13
0.3	41	34	29	25	22	20	18	17	15	14	13	12	12	11	10	10
0.4	32	26	23	20	17	16	14	13	12	11	10	10	9	8	8	8
0.5	25	20	17	15	13	12	11	10	9	8	8	7	7	6	6	6
0.6	18	15	13	11	10	9	8	7	7	6	6	5	5	5	4	4
0.7	13	11	9	8	7	6	6	5	5	4	4	4	3	3	3	3
0.8	8	7	6	5	4	4	3	3	3	3	2	2	2	2	2	2
0.9	4	3	2	2	2	2	1	1	1	1	1	1	1	1	1	1

TABLE 1

Scale factors (α) for water supply installations

S. No.	Components	Scale Factor (α)
1.	Intake	0.1
2.	Elevated Service Reservoirs	0.4
3.	Pipeline	0.5
4.	Treatment Plant with Filtration	0.7
5.	Ground level Reservoirs	0.7
6.	Secondary Sewage Treatment Plants	0.9

2.1 *Demand and Capacity of the Project:*

A typical graph of time interval (t) versus demand and capacity of a water supply project is shown in Fig. 1. For the sake of computational convenience, Manne (1967) has shown it as a straight line which implies that the demand has to grow at a continuous arithmetic rate over time. Slope (D) of the line represents a yearly demand. The capacity (V) of a plant, considering a constant value of D, over a time period shall be

$$V = D.t \quad \text{......} (2)$$

Assuming that the discount rate (r) and economies of scale factor (α) remain the same over time, Manne proposed that the optimal policy should be to build successive plants of the same size at equal time (t) intervals (Fig. 1). A plant life has been assumed to have an infinite time period in the development of his model. Dotted line in Fig. 1 shows step function of cumulative installed plant capacity which, for all the time, satisfies the demand. Putting Eq(2) into Eq(1), we get:

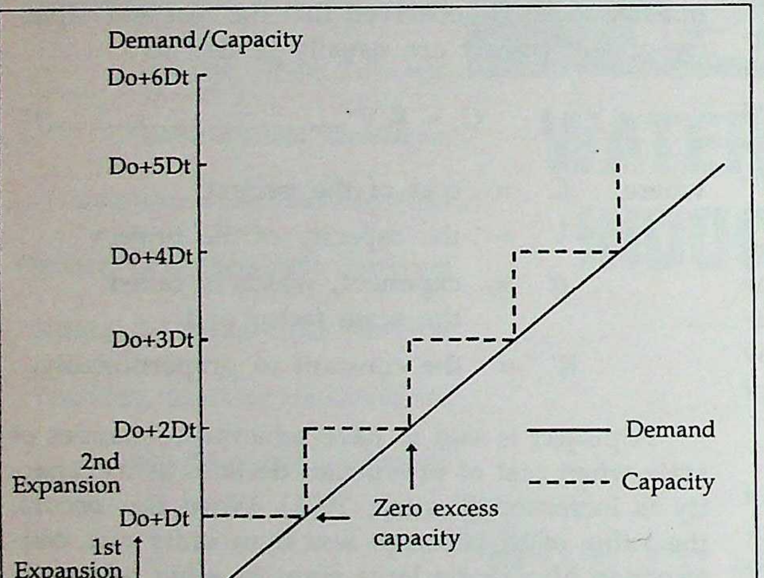

Fig. 1
Demand and plant capacity

$$C = K' D^{\alpha} t^{\alpha} \quad \text{......} (3)$$

Eq(3) can be further written as

$$C = K t^{\alpha} \quad \text{......} (4)$$

where: $K = K'D^{\alpha}$. After every time interval t, a plant is to be expanded. Manne further stated that these successive expansions would have identical undiscounted investment cost C ($= Kt^{\alpha}$). He defined C(t) as the function of t representing sum of all future discounted costs. Rachford *et al* (1969) have also derived the same recursive equation as:

$$\begin{aligned} C(t) &= Kt^{\alpha} + Kt^{\alpha}.e^{-rt} + Kt^{\alpha}.e^{-2rt} + Kt^{\alpha}.e^{-3rt} \\ &\quad + \ldots . + Kt^{\alpha}.e^{-nrt} \\ &= Kt^{\alpha}(1 + e^{-rt} + e^{-2rt} + \ldots + e^{-nrt}) \quad \text{......} (5) \end{aligned}$$

where: e^{-rt} = continuous present worth factor or discount factor for costs incurred t years in future

n = number of expansions.

After rearranging Eq 5, we get

$$C(t) = Kt^{\alpha}[1 + (e^{-rt})^1 + (e^{-rt})^2 + (e^{-rt})^3 + \ldots + (e^{-rt})^n] \quad \text{....} (6)$$

In Eq 6, the terms in square brackets represent a geometric series which converges so long as e^{-rt} is less than one. Taking summation of the geometric series and putting value of n as ∞ (because of assumption of infinite time intervals), Eq 6 becomes

$$C(t) = \frac{Kt^{\alpha}}{(1 - e^{-rt})} \quad \text{......} (7)$$

An optimal cycle time(t) is the one at which the discount cost of all future expansions including the first installation is the least. Hence, for minimizing the cost, the derivative of C(t) with respect to t has been equated to zero, resulting

$$\frac{d}{dt} C(t) = \frac{d}{dt} \left[\frac{Kt^{\alpha}}{(1 - e^{-rt})} \right] = 0 \quad \text{......} (8)$$

Optimal capacity expansion and scheduling of water supply schemes — Application of an economic model

Dr. Sanjay V. Dahasahasra*, **Hemant K. Joshi**** and **Devesh P. Singh*****

Abstract :

Cost of water supply and treatment projects is very high, particularly if the transportation distance between the source and the point of distribution is large. Considering this constraint, the planner has to take some crucial decisions as to when and by how much, capacity of the existing project is required to be enhanced. If capacity provided is less than required, then social problems would often arise. On the contrary, if capacity provided is more than required, it will be a wastage of money. Therefore, there should be a trade-off between these two extremities. This paper discusses application of Manne's economic model, which determines optimal capacity and also suggests optimal interval between successive expansions of the water supply systems. CPHEEO, Ministry of Urban Affairs, Government of India issued guidelines for the design period of various components of a water supply project which are based on the concept of immediate stage (upto first 15 years from the year of commissioning) and ultimate stage (next 15 years). This concept is cross-examined in this paper, with the help of the model. Practical cases of capacity expansion of Amravati and Jaipur cities have also been discussed in this paper.

1. Introduction :

Population of Indian cities is growing at a great pace due to rapid urbanization. Therefore, to meet the rise in demand, existing water supply systems need capacity expansions after a certain interval of time. Cost of the project as a whole and even the cost of components like transmission main etc., are quite high, especially when the source is considerably away from the city. While planning such project, it is to be decided as to when and how much capacity of the existing system is required to be expanded. It is always preferred to defer capital investment as long as possible, because of the **time value of money**. If capacity expansion is more than required, it will be a wastage of money. At the same time, if capacity provided is less than required, it may create social problems including law and order problems caused due to inadequacy of water, especially in summer.

This paper, therefore, discusses application of the well known Manne's model which suggests optimal capacity and interval between successive expansions of water supply systems. The model is based on the concept of economies of scale factors and the rate of interest of a loan. A computer program, in C language, is also presented to compute the various scale factors.

Design period is one of the important parameter in the design and planning of various components of a water supply project. CPHEEO, Ministry of Urban Affairs, Government of India proposed the design period in two stages : (i) immediate stage, which lasts upto first 15 years from the year of commissioning of the project, and (ii) ultimate stage, which is considered for next 15 years. While designing water supply schemes, this practice is being adopted almost in all the states of India. Water treatment plant is generally designed for the immediate stage and the pipes and conduits are designed for the ultimate stage. Fitness of this concept is cross-examined in this paper, with the help of Manne's model. Practical cases of capacity expansion of Amravati and Jaipur cities have also been discussed.

2. Manne's model of economies of scale :

Manne (1967) introduced the concept of economies of scale. He observed that the cost and capacity of any project are usually related as :

$$C = K'V^{\alpha} \qquad \text{.......(1)}$$

where, C = cost of the project
V = the capacity of the project
α = exponent, which is called the scale factor and
K' = the constant of proportionality.

A project is said to have achieved economies of scale when cost of production declines as its capacity is increased (Pratten, 1971). When this occurs, the value of α becomes less than unity and construction of a single large plant or a big scheme is favoured which can take full advantage of the scaler effects on cost (Rachford *et al*, 1969). The value of α mainly depends upon location of the project and the choice of the technology adopted. In the absence of actual data, the economy scale factors for the water supply installations may be assumed as mentioned in Table 1 (Mujumdar, 1992).

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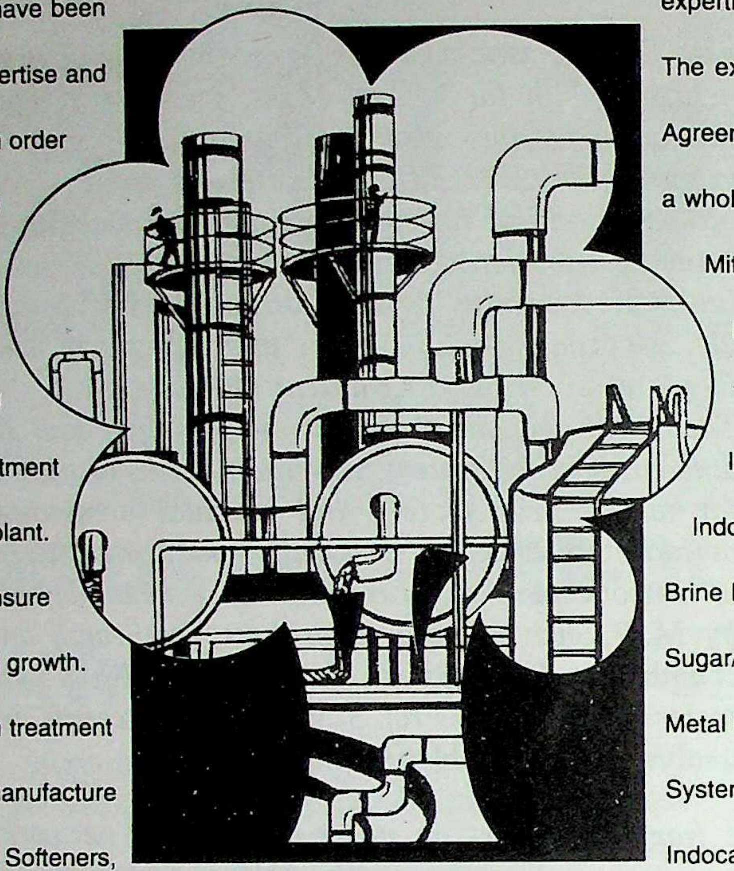

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Editorial

Water distribution systems form a major component of water supply schemes. In this issue, we are publishing five technical papers on different aspects of distribution system design, optimisation and synthesis. In addition, four other technical papers are included which cover areas of water resource and water treatment.

Paper by Dahasahasra et al dwells on the issue of expansion of distribution networks with the help of Maine's economic model. An application of the model for the cities of Jaipur and Amravati shows the need to reexamine the CPHEEO guidelines for the design period. Kansal et al present a critical review of optimisation techniques applied to branched water distribution systems. A comparison of the techniques shows that linear programming based algorithms should be preferred for seeking the global optimum solution. An interesting paper has been presented by Gupta et al on the intermittent and continuous modes of water supply. Their field assessment carried out in Jaipur and Nagpur, illustrates the differences in the system response in terms of water demand, unaccounted for water, peak factors and residual pressures. Research work on optimisation of water distribution networks rarely addresses the issues of network morphology in terms of its redundancy and reliability. Paper by M. P. Shah presents algorithms TreeSearch and Redundancy to accomplish such objectives. Manifold design is a specialised application of water distribution. Prof. S. Vasudevan presents in his paper, a critical analysis of manifold fluid flow theories.

Apart from the papers on water distribution networks, this issue contains two technical papers on the area of water resources, viz., Inter basin transfer of water and Hydrological drought assessment by Ravikumar and Karmegam. A paper by S. V. Shelkikar, brings to you the 'white paper' on the drinking water supply schemes in the rural areas of the Maharashtra state. On the topic of water treatment technologies, Dr. Kardile reports on the improvements done at some of the existing slow sand filters at Malmatha.

In addition to the technical papers, the issue, as usual, carries short communications, discussions and news. I do apologise for the delay in bringing out this issue, but sincerely hope that the readers will find the contents interesting and useful. We will do our best to bring out the next issue on time.

Prasad Modak

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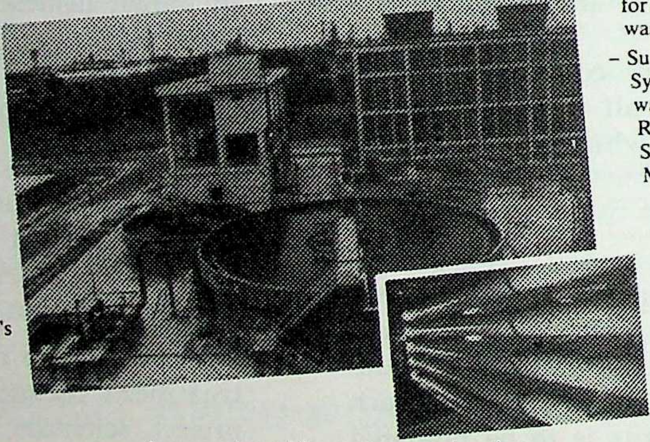

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29th Annual Convention of Indian Water Works Association

3rd to 5th of January 1997 at Calcutta.

The 29th Annual Convention of the Indian Water Works Association will be held at Calcutta in the State of West Bengal, from 3rd to 5th Jan., 1997. The theme for the convention is **'Challenges in Water Supply Systems — Materials, Equipments, Plants, Machinery and Management'**, and the sub-themes are:

1. Water conveyance systems: Pipes, Valves & Controls.
2. Pumping machinery and electrical equipment.
3. Geophysical exploration and instruments.
4. Tubewell materials and drilling equipment.
5. Material and equipment for water treatment plants.
6. Instrumentation, Automation and Computer Application.
7. Pipe corrosion & its remediation, refurbishment of pipes.
8. Costing, affordability and financing of Megacity Water Supply Systems.
9. Advances and Innovations in Water Treatment.
10. Special treatment techniques in regard to arsenic, fluoride, iron and salinity.
11. Management of Handpumps with particular reference to Community based approach.
12. Operations and maintenance of Rural Piped Water Supply Systems.
13. Management of Water Supply Systems in Hilly Areas.
14. Water Quality Surveillance and Monitoring.

More information about the convention will be sent separately by post to all the members of IWWA through a brochure which is now under preparation.

Call for Papers:

Papers are invited from prospective delegates and interested persons dealing with Water Supply Systems on Sub-themes, for presentation in Technical Sessions of the Convention. Synopsis of each paper, not exceeding 200 words is to be prepared by the authors. Copies of the full text alongwith two copies of their synopsis are to be sent to the Chairman or to the Hon. Secretary of the Calcutta Centre of IWWA at their following address.

Prof. A. K. Adhya
(Chairman)
Sanitary Engg. Department
All India Institute of
Hygiene & Public Health
110, Chitta Ranjan Avenue,
Calcutta-700073.

Mr. S. K. Chakraborty
(Hon. Secretary)
Superintending Engr.
Mech. Circle-II, PHED
4th floor, flat-19,
8, Ho Chi Minh Sarani,
Calcutta-700071.

Last date for receiving papers is 15-10-1996.

The selected papers will be published in the technical volume to be released during the 29th Annual Convention. The authors may please note that they will have to attend the convention personally to present their paper, if accepted, and IWWA does not have any grant to support their T.A. & D.A. etc.

Jal-Nirmalata Puraskar

by IWWA

We have published in the January 1996 issue of this Journal on its page 8, full details about the award mentioned above. Information about nominations to be received for this award is repeated below, so that readers of this journal will be able to suggest suitable nominees for the award and also send information about their contribution to the subject, latest by 10-10-1996 to IWWA H.Q. in Mumbai, at Pipeline Road, Vakola, Santacruz (E), Mumbai-400055. The selected nominee of this (1996-97) year will be felicitated with this award during the Annual Convention of the Association to be held from 3rd to 5th January 1997, at Calcutta.

Criteria for nomination of an awardee are:

(i) The awardee should be an Indian National or an Indian Institution.

(ii) His/its work should be associated with the Indian issues and Indian scenario and be preferably carried out in India.

(iii) His/its contribution can be in the field of science, engineering, management or social mobilisation, but the main target of achievement should be improvement in the quality of water for human/cattle life.

(iv) The contribution may be in the form of a new treatment technique, implementation of a project, scientific invention, administration of a supply system or development of a social organisation, or methods and procedures for protecting the quality of water.

Private Sector Participation in Water and Waste Sector

23-26 September, 1997 at Holiday Inn, Goa

An International Workshop

organised by

Indian Water Works Association (Mumbai Centre) and **Indian Environmental Association**

Private Sector Participation (PSP) has become an attractive option today for meeting the ever increasing shortfall in water and waste management systems in Asia. By any statistics, this shortfall is staggering and stupendous efforts are required to look for financial resources, especially from the private sector. Further, a well structured institutional set up is required to be devised with financial models drawn up to attract private investments. Accordingly, contractual frameworks and design and performance criteria will have to be evolved deviating from the traditional models of the contract conditions. Careful attention will also have to be given on the concomitant environmental and social impacts and towards the management of risks.

Recently, the wheel of privatisation in the water and waste sector has started rolling in the Asian region and projects on BOOT basis have started appearing in the market. Recognising the relevance and importance of such projects, the Indian Water Works Association (Mumbai centre) and the Indian Environmental Association have planned a three-day highly interactive international workshop.

The workshop will be a residential one restricted to about 100 participants. It is intended to be a highly interactive workshop providing a platform to high level officials from the public sector governing bodies, consultants, contractors, user representatives as well as the multilateral and bilateral financial institutions to share their experiences, successes and even failures in the implementation of the PSP contracts for the water and waste management systems in their regions and in Asia in particular.

The scope of discussions will include Water Supply & Wastewater Systems as well as Solid and Hazardous Waste Management Systems.

For more information, please address inquiries to:

Dr. Prasad Modak
Workshop Leader
105, Hanuman Industrial Estate,
42, G. D. Ambekar Marg, Wadala, Mumbai-400031.
Tel.: 91-22-4168217 Fax: 91-22-4139125
Email: pmodak@giasbm01.vsnl.net.in

Programme for the abovementioned workshop has been decided tentatively as follows.

Tuesday, 23rd September 1997:

17.00 hrs.	Inaugural Function
18.00 hrs.	High Tea
18.30 hrs.	Theme Address
19.00 hrs.	Country Presentations
20.30 hrs.	Welcome Dinner

Wednesday, 24th September 1997:

09.00 hrs.	Models of Privatisation
09.30 hrs.	Case Study of Model 1
10.00 hrs.	Case Study of Model 2
10.30 hrs.	Tea/Coffee
11.00 hrs.	Case Study of Model 3
11.30 hrs.	Case Study of Model 4
12.00 hrs.	Discussion — Case Studies
13.00 hrs.	Lunch
14.00 hrs.	Opportunities in India 1
15.30 hrs.	Tea/Coffee
16.00 hrs.	Opportunities in India 2
17.30 hrs.	Break
18.30 hrs.	Goan Dinner

Thursday, 25th September 1997:

09.30 hrs.	Commercial Session 1
11.00 hrs.	Tea/Coffee
11.30 hrs.	Commercial Session 2
13.00 hrs.	Lunch
14.00 hrs.	Visit to Salavali Water Supply Project
18.00 hrs.	Barbeque Dinner

Friday, 26th September 1997:

09.00 hrs.	Way Ahead!
12.00 hrs.	Valedictory Lunch

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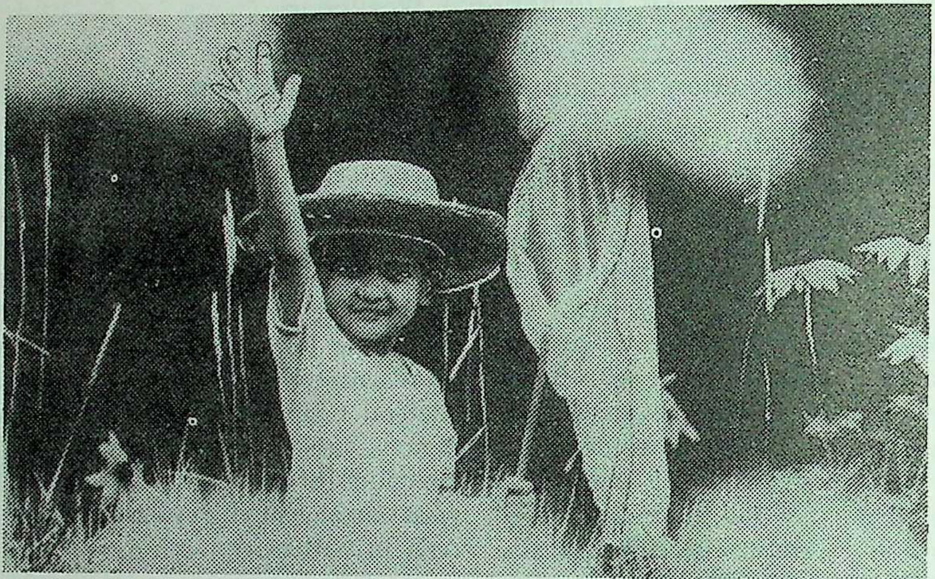

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Water Conservation in Agricultural Lands

H. J. Shiva Prasad* and **Mrs. Jyothi Prasad****

Introduction :

Conservation is defined as preservation against loss of waste i.e. putting the water resources of the country for the best beneficial use with all the technologies at our command.

Possibilities of water conservation may be either by increasing supply or by reducing demand.

Water supply can be increased by improving the existing water systems, without a complete new installation, e.g. lining of canals will reduce seepage losses, or replacing canals with closed conduits of plastic, concrete, metal etc. will reduce evaporation.

Reasonable amount of water can be saved by improving water management on the farm i.e. proper design of on-farm distribution and drainage systems between farm fields. The system must deliver the right amount of water to the user at the right time and water should not be delivered in an arbitrary and inflexible manner.

Various ways of conserving water and adjusting crops and agricultural practices are described in brief in this article.

Rainfall harvesting :

Rainfall fluctuates widely from region to region, season to season and year to year. In our country normal annual rainfall is as low as 100 mm in Western Rajasthan and is over 11000 mm at Cherapunji in Meghalaya. The spatial unevenness and temporal variation in precipitation has led to complex situation like distinctly different monsoon and non monsoon seasons and the high and low rainfall areas. The problem of large variation in water availability and growing demand leads to water harvesting.

Water harvesting refers to the deliberate collection of rain water from a surface (catchment) and its storage to provide a supply of water (10 mm of rain equals 100 cubic meters of water per ha.). Harvesting rain water can provide water for region where other sources are too distant or too costly, or where wells are impractical because of unfavourable geology or excessive drilling costs. Rainfall harvesting is particularly suited to supplying water for small villages, schools, households, small gardens, live stock and wild life.

Rainfall runoff can be collected from an untouched natural catchment by digging ponds in small depressions. Catchment modifications by making the soil more impermeable to increase the amount of runoff can be done. Land alterations by constructing ditches or rock walls along hill side contours may be needed to collect and convey runoff water. Even clearing away rocks and vegetation increases runoff water. Rain water can also be harvested by compacting the soil surface, treating soil with chemicals that fill pores or make soil water repellent. Water repellent chemicals such as silicones, latexes, asphalt and wax are used. On porous or unstable soils, the water shedding surface may be covered with a waterproof cover like plastic sheet, Butyl rubber, Metal foil etc.

In humid and sub-humid regions where rainfall of considerable intensity is spread over large part of the year, roofs made up of tiles or corrugated galvanised iron are used to harvest rain water. The runoff from roof tops is collected in different kinds of storage tanks which can be above or below ground.

Runoff agriculture :

Perennial crops with deep root system are preferred because they can use runoff water stored deep in the soil, safe from evaporation. Short lived crops like pearl millet can be grown, that mature rapidly and require one rainfall. Also plants that become dormant during dry periods and begin growing when water becomes available are preferred for conservation.

(a) *Water Spreading :*

In arid areas the limited rainfall usually falls as short and intense storms. The water swiftly drains away in to gullies and then flows towards the sea or an inland lake. Water is lost to the region and floods caused by this sudden runoff can be devastating, often to areas otherwise untouched by the storm.

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Water spreading is a simple irrigation method for use in such conditions i.e. flood waters are deliberately diverted from their natural courses and spread over adjacent flood plains or detained on valley floors. The water is diverted or retarded by ditches, dikes, small dams or brush fences. The wet flood plains or valley floors can then be used to grow crops.

(b) *Micro catchment farming :*

A plant can grow in a region with too little rainfall for its survival if a rainwater catchment is built around it, forcing rainfall from a larger than normal area to irrigate the plant and is called micro catchment farming.

Micro catchments are more efficient than large scale water harvesting schemes because conveyance losses are minimized. It is much cheaper to convert a certain area into micro catchments than to construct a runoff farm because micro catchments do not need channels, landwits, terraces and terrace walls. This method is suitable for deep rooted crops such as trees and shrubs, which can tap stored water from deep soil and depend less on frequent rainfall.

Irrigation with saline water :

Beneath many of the world's deserts are reserves of saline water, and many surface water estuaries, coastal lagoons, land locked lakes, and irrigation return flows contain fairly large amounts of salt. Their saline water may be used for irrigation to grow tolerant crops like cotton, barley, wheat, sugar beets, rye grass, bermuda grass, wheat grasses etc. and trees like date palm, olive, pomegranate, pistachio etc.

Reusing water :

Overall demand for water resources can be greatly reduced by reusing waste water for irrigation, for industry, for recharge of ground water, for municipal supply.

(a) *Agricultural use :*

Reclaimed water by spreading waste water on marginal land to create new farm land in arid region may be used for irrigation. Filtering waste water through soil removes all particulate matter; most cations and some anions are strongly adsorbed and organic matter is decomposed by soil bacteria. These actions can contribute plant nutrients to soil.

Using Municipal waste water for irrigation is much attractive where agricultural lands are located close to cities, because the plant nutrients in sewage are useful. Little biological treatment of sewage may be required before land application.

(b) *Industrial Use :*

Municipal waste water from secondary treatment plants can be used for cooling, ore separation and other purposes that do not have severe water quality requirements.

(c) *Municipal Use :*

Waste water after secondary and tertiary treatment may be used for flushing of toilets, watering of lawns and gardens.

Other sources of water :

(a) *Ground Water Mining :*

Deep well techniques can be applied to productive aquifers in arid regions which store large quantities of water.

(b) *Sea Water :*

Low cost desalting of sea-water to arid lands or for domestic supply bordering seas or salt lakes.

(c) *Artificial rain through cloud seeding :*

Certain cloud formations contain super cooled water. Bombarding common salt/frozen carbon dioxide/silver iodide crystals etc. promotes condensation (Nucleation) of super cooled water. Limitations of this method are to have the right meteorological conditions, the imperfect knowledge of the physical processes causing precipitation, and engineering difficulties in getting seeds into clouds in optimum amounts and at the right time and place.

(d) *Icebergs :*

Ice which constitutes about 85% of the world's fresh water in the polar region can be recovered by towing icebergs to water-short regions and melting them. The method is quite costly and usable where water is scarce and seacoast is nearby.

(e) *Reducing evaporation from water surface :*

Reservoirs and canals are subject to heavy evaporation losses which can be reduced to increase the supply of water. Reducing evaporation can be done by covering the water surface with a barrier that inhibits vaporisation.

Liquid chemicals like Aliphatic alcohols e.g. Cetyl alcohol that automatically spread out forming a sealant layer across the water surface.

Other approaches include locating reservoirs at high attitudes, keeping a lower area/volume ratio of water body, minimising exposed surface through reservoir regulation, reducing energy available for evaporation, and installing wind breaks.

Evaporation control is an important way to conserve water because it requires no new construction and the additional water becomes available without additional construction cost and delays.

(f) *Reducing seepage losses :*

For economic reasons most arid lands use earth canals and reservoirs. Because their soils are often porous, many of these storage facilities and conduits suffer serious water losses through seepage. In diverting water from its intended purpose, seepage can also cause serious water logging, salinification and erosion of neighbouring soil.

Seepage can be reduced if the walls of reservoirs and conduits are made water tight. This can be done by soil compaction, chemical treatment of soil and soil cover such as butyl rubber, sheet plastic, L.D.P.E. film asphalt reinforced with plastic or fibreglass and ferrocement concrete filled fabric etc.

(g) *Reducing evaporation from soil surface :*

Evaporation from soil surfaces wastes larger amounts of water in arid and semi arid lands, where low humidity greatly encourages evaporation. This loss can be reduced and irrigation water saved by placing water-tight moisture barriers or water retarding mulches on the soil surface or by creating wind breaks of trees, fences or taller growing plants. These barriers will also stabilize loose soils, stop encroachment, allow runoff agriculture, help in landscaping and reduce salinity build-up.

Soil surface barriers are made of non porous materials such as paper, asphalt, latex, oil, plastic film or metal foil etc. and even a 5-25 mm thick layer of thick porous material (i.e. plant residues such as straw, saw dust, wood bark, cotton burs as well as gravel, sand or cinders).

Chemicals such as silicones, poly ethylene, oxides, pollyaccharide gum mixtures, fatty alcohols and cationic, anionic and nonionic chemicals have been used as evaporation suppressants.

(h) *Sprinkler irrigation :*

On the irrigated area water is sprinkled by sprinklers fed by conduit or by irrigation equipment fed from canals or low pressure pipe conduits. The advantages compared to other methods are as follows :

- ☐ the possibility of accurate water supply control.
- ☐ the economical consumption of water (efficient use 80-90%).
- ☐ it does not stand in the way of tillage, thus eliminating evaporation and seepage losses.
- ☐ at correct intensity it does not damage the soil structure, does not oversaturate it with water and does not cause erosion even on sloping land.
- ☐ it is suitable for all plants for supplemental irrigation, for fertilizer irrigation and for protective irrigation.
- ☐ it allows for mechanised and automated operation of the irrigation system resulting in water conservation.

Disadvantages include higher capital and running costs, and considerable evaporation in arid land from the surface of the irrigated crops.

Water losses in sprinkler irrigation occur by leakages from the distribution pipe line, evaporation of water into the atmosphere during sprinkling, discharge of water to areas outside the irrigated area, infiltration into the non vegetation soil profile. With proper management one can control the losses except evaporation.

(i) *Trickle/Drip irrigation :*

Standard irrigation methods are particularly wasteful of water because the extended areas of wetted soil greatly encourage evaporation. Drip or trickle irrigation uses a system of plastic pipes placed among the plants on or under the soil. Water carried in the pipes drips on to the soil through outlets arranged near each plant. Because only a small amount of soil is watered,evaporation losses are minimized. Furthermore, the rate and time of water application are adjusted for no runoff and minimal deep percolation losses.

It is used extensively on tree, vine and row crops, but because of high costs it is not yet used much for field crops. Trickle irrigation is applied where land levelling for conventional irrigation is prohibitively expensive or impossible i.e. steep slopes or rocky areas, water is scarce or expensive, the soil is too porous or too impervious for gravity irrigation, water quality is poor, it is too windy for sprinkler irrigation, trained irrigation labour is not available, irrigation labour is expensive.

Trickle irrigation not only improves the efficiency of water use but also gives much greater control over the placement and amount of water. The amount of water can be adjusted to the soil's absorptive capacity and to the characteristics of the particular crop, its stage of growth, and the climatic conditions. Thus, unlike other irrigation methods, trickle irrigation minimizes surface standing water, which can breed mosquitoes and increase water logging and anaerobic conditions that adversely affect plant growth.

Surface irrigation methods may require expensive land preparation and continued land maintenance which may not be there in trickle irrigation. Fertilizers can be applied through the trickle system and efficiently applied close to the roots. Because the irrigation water never touches the leaves, foliar salt damage is not a hazard with trickle irrigation. Many moisture induced leaf and stem diseases fostered by other methods of irrigation are minimized or defeated by trickle irrigation, which may also help to control pathogens that develop in water logged soils. Because in trickle irrigation water drops on the soil without disturbing the surface, soil erosion and surface crustation, which impede water penetration are usually eliminated.

(j) *Reducing Crop land percolation losses :*

Growing in sandy soils requires frequent irrigation. Sandy soils are low productive due to their inability to prevent water from percolating away too rapidly for plant growth. Growing crops in sandy soils thus requires frequent irrigation.

Artificial underground moisture barriers that keep water and nutrients from percolating below the root zone are provided. These moisture barriers are continuous films of a water resistant material like asphalt, plastic sheets, or layers of compost or manure rich in colloids.

Unlike many other soils, sand has a surface, durable enough to withstand the abuses of tillage and farming. It allows quick intake of rainfall or irrigation water; its good capacity for aeration favours root development and its upper layers often serve as a mulch, reducing losses from evaporation.

A barrier gives sandy soil a storage capacity equivalent to that of a better agricultural soil in a temperate region. Thus, barriered soils require less frequent irrigation than unbarriered soils. Barriers prevent fertilizers as well as water from sinking below the root zone.

(k) *Reducing transpiration :*

Transpiration differs from evaporation in that it takes place on living tissue and is influenced by the physiology of the plant. Out of the water absorbed by roots only 1% is incorporated in to the plant cells and the remaining moves up through the plant and passes in to the atmosphere as water vapour.

Transpiration losses can be reduced by the following ways.

(i) Destroying unwanted phreatophytes that transpire efficiently e.g. Salt Cedar, mesquite.

(ii) Enclosing crops within structure so that transpired water can be collected and reused or so that the humidity rises and retards transpiration losses.

(iii) Breeding plant varieties that transpire less.

(iv) Reducing air movement over a crop e.g. Wind breaks of interplanted rows of taller plants.

(v) Removing unproductive leaves physically or with defoliants.

(vi) Using chemical antitranspirants.

Chemical antitranspirants work by — (a) closing stomata (b) Forming a film over the stomata (e.g. Cetyl alcohol, Silicons, Wax, Latex and plastic etc.) (c) Cooling the leaf with reflecting coat that reduces the amount of solar energy absorbed.

Items (ii) & (vi) above are costly and not practicable for raising general food grains in our country.

(l) *Selecting and Managing crops to use water more efficiently :*

This can be done by the following ways.

- Plants that grow in cool seasons when evaporation rates are lower (e.g. Lettace).
- Rapid growing plants that shorten the time in which water is lost by transpiration and evaporation.
- High yielding plants that require no appreciable increase in water supply.
- Plants with low transpiration losses e.g. Agave and pineapple.

○ Plants that can tolerate low quality water (e.g. saline).

Crop management that increases production also increases water efficiency. Insufficient fertilizer, insect control or disease control, improper cultivation and excess weeds all reduce the yield and thus reduce water use efficiency. Cultivating crops in rows on the contour increases infiltration of rainfall and reduces water and soil losses.

(m) *Controlled environment Agriculture :*

High agricultural productivity can be achieved with limited amounts of water, by encapsulating crops within specially developed (transparent) enclosures. Water normally lost by seepage evaporation and transpiration is retained and reused within the enclosure. Inside the enclosure light, heat, water, humidity, carbon dioxide, nutrients and pests are manipulated and balanced to produce yields many times larger than that of outdoor agriculture. This method is however not practicable for adoption on large scale in our country due to high cost and technology requirements.

Other promising water conservation techniques :

(a) *Hydrophobic soil amendments :*

Irrigation water is lost in evaporation or it sinks below the root zone. Hydrophylic (water attracting) chemicals can absorb water, holding it safe from evaporation or further dissipation. Soil mixed with such chemicals becomes sponge like, trapping and retaining water for an extended period. The water is available for plant roots which can draw on it as required. e.g. Hydrophobic starch copolymers (Super slurpers), crushed brown coal.

(b) *Artificial recharge of underground reservoir :*

Water removed from underground aquifers will be replaced by natural recharge. To replenish the water table, surface water can be used to artificially recharge. Artificial recharge can be done through wells or pits which are drilled to gain entry into the aquifer or spread on the land, so that it percolates through the soil to the aquifer. Pits are used at shallow depth aquifer, wells at deep aquifers and spreading when aquifers are exposed at the surface.

Artificial recharging of ground water provides readymade storage reservoirs, free from evaporation and protected from evaporation, avoids saline water from intruding in to the aquifer and soil from subsiding in to empty space in a depleted aquifer, and also to reclaim waste water.

(c) *Inter basin transfers :*

Here transfer of surface water from surplus areas to drought prone areas wherever feasible and appropriate, is made such that the natural runoff does not flow waste to the sea e.g. Telugu Ganga project.

Development of canal grid systems through linking all the important rivers in order to harness flows, providing water facilities from no need regions to needy tracts and developing a cheap transport system.

(d) *Water conservation by Public awareness :*

Perception and knowledge of important water issues relevant to national soci-economic planning must be communicated to planners and decision makers. Open planning processes and public participation are important means for community awareness.

Selected References :

1. Rainfall harvesting — National Institute of Hydrology, Roorkee 1993.
2. Water Conservation — National Institute of Hydrology, Roorkee 1993.
3. More water for arid lands — Promising technologies and research opportunities — National Academy of Sciences. Washington D.C. 1974.
4. Irrigation Structures — Milos Holy CBID New Delhi — Publication No. 135 1984.

Attention !
Subscribers and Members of IWWA

A special volume containing papers to be presented at the 29th Annual Convention of IWWA to be held at Calcutta from 3rd to 5th of January 1997 is being published. The subscribers to the Journal of IWWA and members of IWWA who may not be attending this convention can obtain this volume at a concessional price of Rs.200/- (including postage by regd. post) if they book their order in advance by sending their requisition and a demand draft of Rs.200/- issued in favour of the Organising Secretary, 29th Annual Convention of IWWA on the address given below.

Mr. S. K. Chakraborty
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A-8/7, Bidhan Absan (RHE), F.B. Block,
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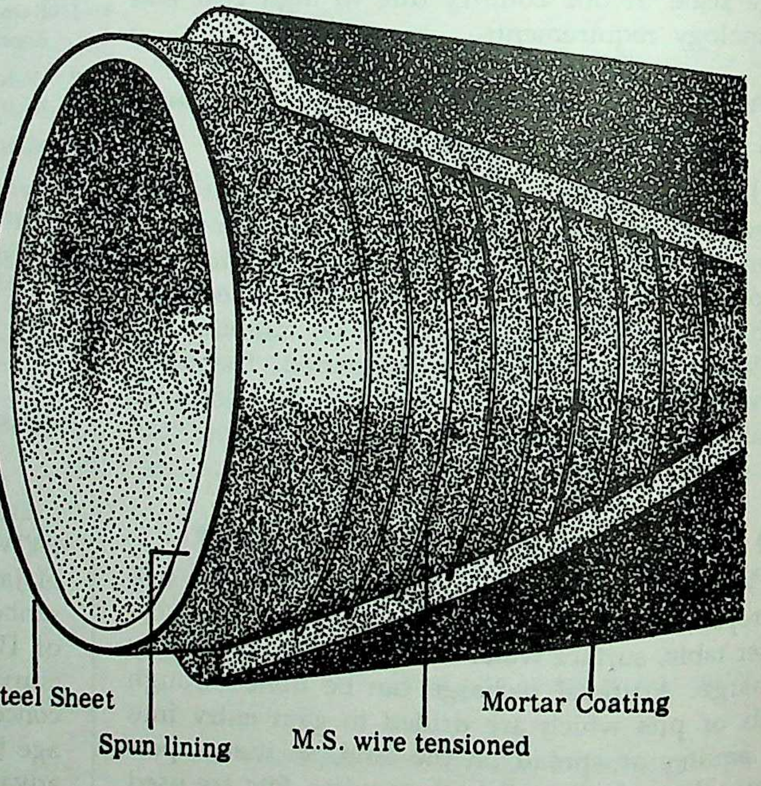


A Non-conventional Water Filtration Plant of 2 mld Capacity for East Part of Gondal City (Gujarat)

J. B. Kagathara*, M.E. (Enviro) LFIWWA

Introduction :

There are some small Municipalities in our country which supply untreated water to the communities they serve because of lack of proper management, non-availability of trained Engineers to work for them, shortage of funds, and less concern towards water supply works.

The erstwhile princely town of Gondal of Rajkot District (Gujarat) can be cited as an example of such problems where untreated water was being supplied to the population of 90,000 during the period 1971 to 1994 February, inspite of having a good water filtration plant. The Author was given an opportunity to re-store and re-commission this 9.0 MGD water filtration plant and to develop another for the Eastern part of Gondal having population of 20,000.

He took up the challenge and re-stored and re-commissioned the existing conventional type rapid sand filtration plant within 37 days and put it into full operating condition which functions efficiently since April 1994. The restoration cost was only Rs.1.75 lakh.

New water treatment plant for East part of Gondal town :

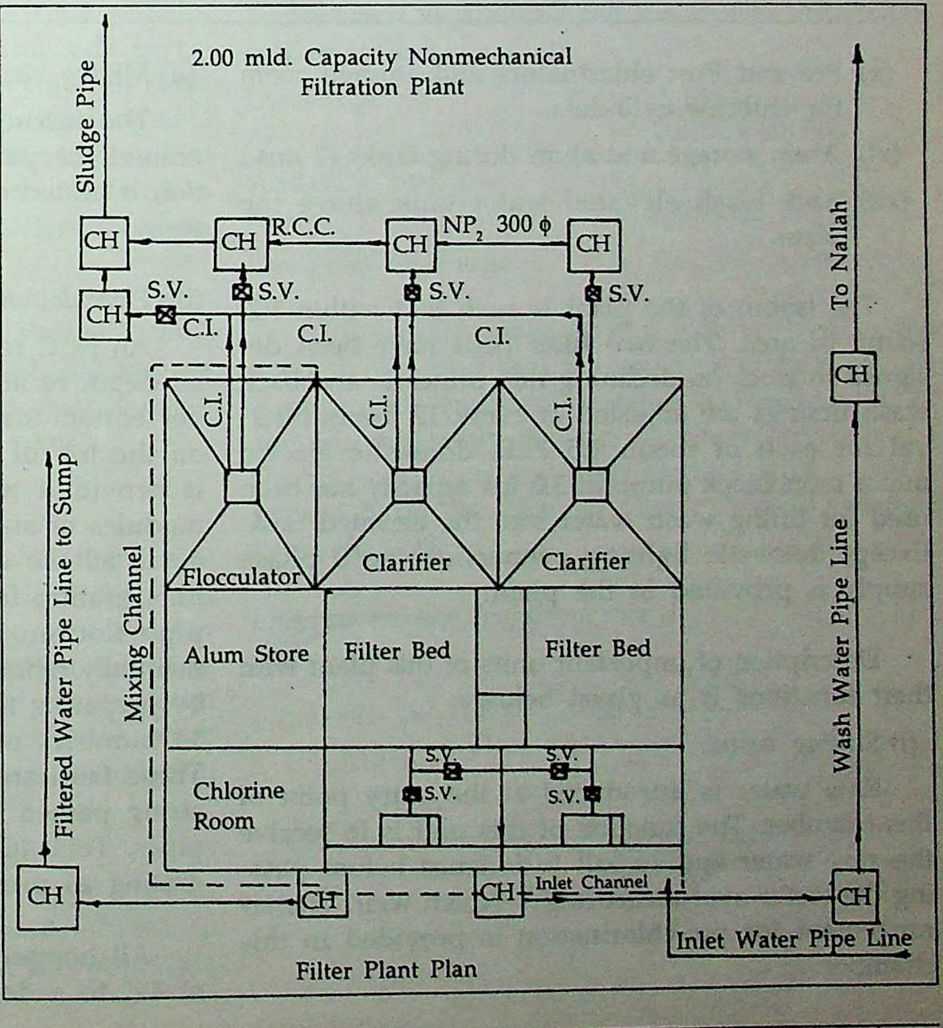
For this part the Author planned a non-conventional rapid sand water filtration plant of 2.0 mld capacity based on the Tube Settler theory and utilized an existing raw water source Setu dam reservoir having capacity of 45 mcft which was constructed by the Municipality 4 years back but could/did not utilise it due to lack of knowledge and proper guidance.

The execution of the filtration plant work was started in July, 1994 and was completed in the month of December, 1994.

This plant is constructed on an area of just 10.22 x 10.42 m. (i.e. 106.49 sq.mt.) with all required components of the plant and constructed as novel type of plant in this region which is handled by only one unskilled person thanks to simplicity of its design and operation.

The plant consists of the following units :

(i) Inlet channel (stilling basin) with measuring device cum mixing weir.
(ii) mixing channel
(iii) Flocculation tank
(iv) Tube settling tank
(v) Settled water channel & collector pipes
(vi) sludge drain and disposal system
(vii) Rapid sand filter beds 2 Nos.
(viii) Wash water drain system
(ix) Pipelines, manifolds and pure water channel and chambers.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Chlorine Room
Inlet Channel
Inlet Water Pipe Line

Filter Plant Plan

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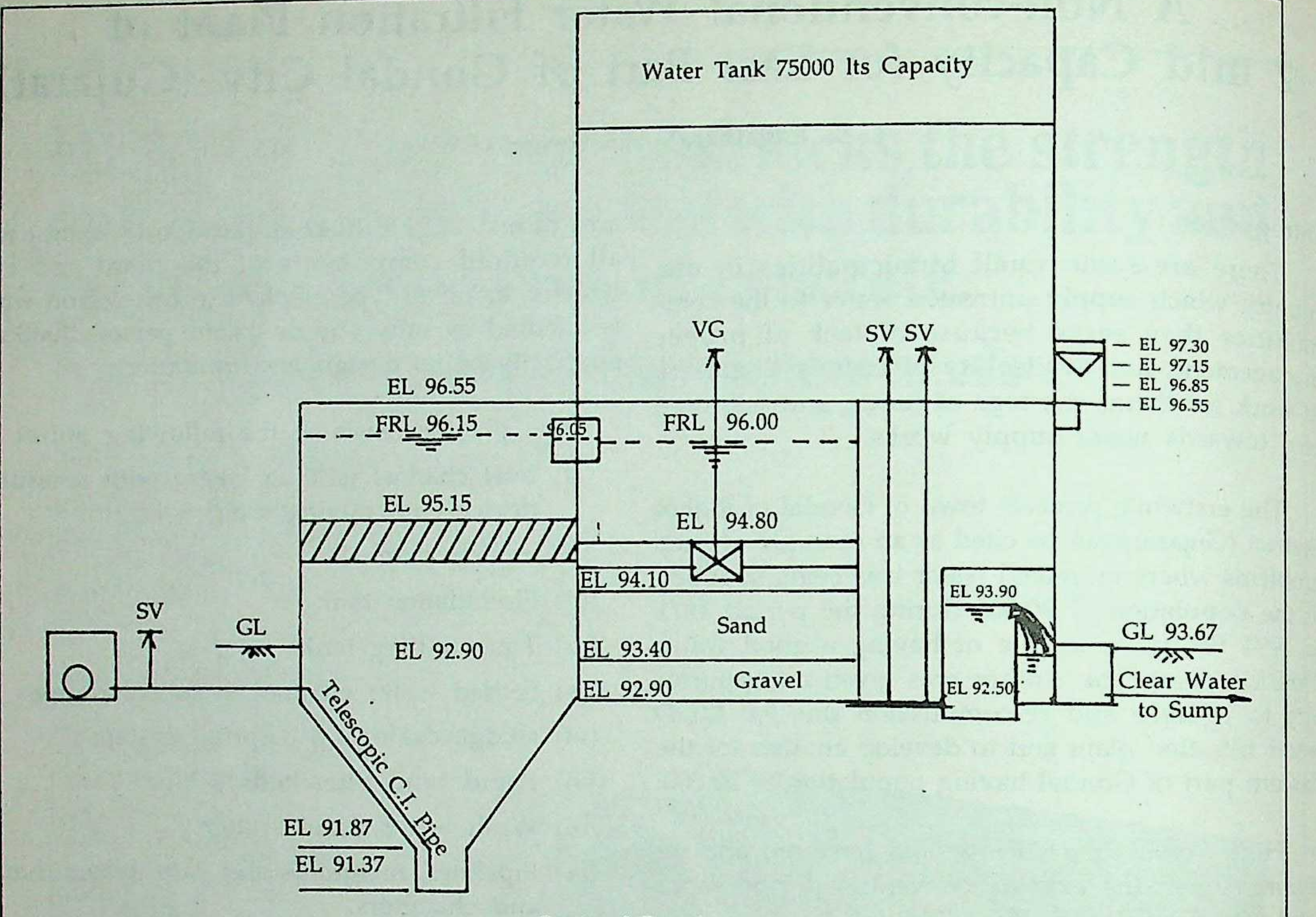
Water Tank 75000 lts Capacity
VG
SV SV
EL 97.30
EL 97.15
EL 96.85
EL 96.55
EL 96.55
FRL 96.15
96.05
FRL 96.00
EL 95.15
EL 94.80
EL 94.10
EL 93.90
SV
GL
Sand
GL 93.67
EL 92.90
EL 93.40
Gravel
EL 92.90
EL 92.50
Clear Water to Sump
Telescopic C.I. Pipe
EL 91.87
EL 91.37

Sectional Drawing

(x) Pre and Post chlorinators and storage room for chlorine cylinders.

(xi) Alum storage and alum dosing tanks (2 nos.)

(xii) Back wash elevated water tank above the plant.

The layout of the plant is such that within 100 sq.mt. of area. The two filter beds have been designed to work on declining rate principle and back wash timings are adjusted at every 12 hours interval for each of them. 1.5 H.P. domestic electro motor monoblock pump of 3.0 lps capacity has been used for lifting wash water into the elevated tank. Except domestic lighting connection, no 3 phase supply is provided in the plant.

Description of important units of this plant with their functions is as given below:

(i) *Stilling basin:*

Raw water is introduced at the entry point of this chamber. The function of this unit is to receive the raw water and to kill turbulence before passing the water over measuring V-Notch weir. The arrangement for pre-chlorination is provided in this chamber.

(ii) *Mixing channel:*

The mixing channel is provided as cantilever around the plant in 20 mt. length. The alum solution is added on the downstream of the measuring weir.

(iii) *Flocculation tank:*

An RCC rectangular tank 2.5 x 3.5 m with overall depth of about 3.25 m from FSL to top of hopper bottom slab is provided. At bottom i.e. resting on the top of hopper level an M.S. grating frame is provided which is used for placing PVC floc modules of size 1.25 x 1.15 x 0.5 m (6 bunches) to cover all the area for 2.0 mt depth on the bottom M.S. grating frame. PVC half cut [50 mm dia size] pipe floc modules of 1.25 x 1.15 x 0.5 m. were manually fabricated by using 50 mm dia PVC pipes by preparing first perforated layers by using 12 and 14 numbers of half cut pipes in alternate layers. These fabricated layers were then tied by a nylon string passed through holes made in the half cut pipes. Total (6 x 4 =) 24 bunches were placed on a grating as prescribed by the CPHEEO Manual.

All hopper bottom slabs were laid at an angle of 45° to a depth 1.8 mt. with 0.6 x 0.6 x 0.30 m.

sludge collection chambers. Sludge from hopper bottoms can be removed by means of an 80 mm dia CI pipe (under hydrostatic pressure). Flocculation time provided is 18 minutes.

(iv) Tube settling tank :

RCC rectangular tank of size 3.5 x 7.23 mt. with water depth of 3.25 m from FSL from hopper top level is provided. At the bottom of the tank, two hoppers are provided with 45° slope for collection of sludge. Sludge draining CI pipes and valve of 80 mm dia are provided. Sludge can be drained through the system under hydrostatic pressure.

Modules of rigid PVC square tubes, of size 50 x 50 mm opening and 0.6 mt. in inclined length but 0.5 mt. in vertical module depth to cover all surface area of the tank have been provided and rest on 100 mm thick RCC carbells in RCC walls on both sides at 1.5 m below FSL to support the tube modules. Tube modules were fabricated by fixing rigid PVC square tubes at 60° angle in opposite directions by means of solvent cement. Groups of five tubes were prepared and then all the modules were fixed on carbells by joining each module with cement solvent one by one. A manhole cum open gap of 0.90 x 3.50 m size was provided for inspection of the tank and further extension of tube settlers. 6 Nos. of PVC 200 mm dia pipes with side perforation of 30 mm dia at 15 cm centres on both sides of collection pipes were provided. One opening side is fixed in the settled water collection channel of RCC section and one end is plugged and fixed at the opposite side RCC wall, Sludge collection chambers and disposal pipeline.

A pipeline drain for disposal of sludge from 3 Nos. of collection chambers is provided. 450 mm dia RCC N2 class wash water pipeline is used to drain the sludge and wash water to the river.

(v) Filter house :

The filter house building 7.5 m x 10.42 mt. size on RCC framed structure with top level of plant building slab as water tank is constructed for economy. Enough passage is provided for installing sluice valves, clear water chambers, channels. Alum storage, chlorinator room, inlet outlet gates, alum dosing tanks, opening door, windows, ventilation etc. in most appropriate way.

(vi) Filter beds :

An RCC structure with filter sand 0.75 mt. in depth and gravel 0.45 mt. below it are provided. 50 mm dia PVC pipes of 6 kg/cm² pressure rating are provided for under drainage system.

Gravel bed material

size mm.	depth cms.
65-38	15
38-20	09
20-12	09
12-05	06
03-02	06
Total	45

Total depth of water in filter box is provided 2.90 mt. so that at a later date both the filter beds can be converted into 'dual media' and filtering capacity of the beds can be increased by 30 to 35%.

Dual media (coconut shell) = 0.40 m
Sand depth = 0.40 m
Gravel depth = 0.50 m
Water Head = 1.60 m
Total = 2.90 m

Important Calculations for the design of tube settler tanks :

Discharge Q = 2 MLD
= 0.02314 m³/sec.

Add 20% overload capacity = 0.004629 m³/sec.

Designed discharge = 0.02776 m³/sec.

PVC square tubes 50 mm size is used in the plant. It is found that performance of tube settlers is improved significantly with L valves of upto 20 and insignificantly beyond 20. Therefore, it is desirable to design the tube settlers with L valve around 20 but less than 40. (Refer CPHEEO Manual Page No. 199).

Effective relative length of tube L :

$$L = LR - 0.058 \times \frac{Vod}{V}$$

$$LR = \frac{600}{50}; \text{ Take length of tube} = 60\text{cm}$$

$$= 12$$

$$\therefore \; L = 12 - \frac{0.058 \times Vo \times 0.05}{1 \times 01 \times 10^{-6} \times 86400}$$

$$= 12 - 0.0335Vo$$

Vo = flow through velocity for tube settler in m/d.

Flow velocity through tubes

SC = Vsc (Sin Q + LCos O)
Constant for square is 11/8

Vsc = 50 permissible surface loading rate $m^3/m^2/d$ for vertical up flow clarifiers as shown in the table CPHEEO Volume Page No. 194.

$$\frac{11}{8} = \frac{50}{Vo}\,[\text{Sin } 60° + (12 - 0.033\ Vo)\ \text{Cos } 60°]$$

$$\frac{11}{8} = \frac{50}{Vo}\,[0.866 + (12 - 0.0335\ Vo)\ 0.5]$$

$$11\ Vo + 6\ Vo = 2746.4$$

$$Vo = \frac{2746.4}{12}$$

$$= 161.55\ m/d.$$

Net Tube entrance area required

$$= \frac{Q}{V} = \frac{99.93 \times 24}{161.55}$$

$$= 14.84\ m^2$$

Overall area provided = 7.23×3.5
= $25.30\ m^2$

Deductions : Central beam carbings manhole cum extension area .. $6.45\ m^2$ (approx)

Net area of tubes = $18.84\ m^2$

Effective area of tubes = 85% of net area
= $0.85 \times 18.85\ m^2$
= $16.02 > 14.84\ m^2$ O.K.

Cost aspects :

The cost of construction of this new plant is about Rs.11.00 lakh on the basis of tenders received. This cost is considerably low in view of conventional plant cost as per the S.O.R. of G.W.S. & S. Board, Gujarat State.

Plant performance :

After the construction of the treatment plant training was given to the water works staff for its operation and maintenance. Since April, 1995, the plant is found to be working smoothly. The maximum raw water turbidity is around 400 NTU during the monsoon period while the average turbidity is between 20 to 30 NTU. The settled water turbidity is maintained between 7 to 10 NTU by adjusting the alum dose. The filtered water turbidity is maintained below 1.0 NTU with occasional increase upto 1.0 NTU.

Acknowledgement :

Author is thankful to District Collector, Rajkot, Administrator of Gondal Municipality, officers, President of newly Elected Body as well as the contractors M/s. Pooja Construction Co., Rajkot, for providing an opportunity to get successful in the project. He is also very much thankful to Respected Dr. Kardile & Shrish Kardile for inspiring to go in for the unconventional design and for providing the tube-settler/s modules in time for speedy completion of the work.

ATTENTION FIELD ENGINEERS

Indian Water Works Association publishes this journal quarterly for dissemination of information and work experience to the waterworks professionals and persons interested in this subject on all matters pertaining to water supply & waste-water treatment and disposal systems. The Association does receive good articles for publishing, from persons working in the teaching and research institutes. However, it very much wants to publish field experiences for which I appeal to all the field engineers to write suitable articles narrating their experiences about works designed/constructed/operated and maintained by them.

This would help the fellow engineers in utilising the information.

— Editor

Dewatering of Water Treatment Plant Sludge by Centrifugation

S. Srinivasan* and Smt. D. Madhivani**

Around 5% of raw water taken into the treatment plants goes as waste by way of clarifier sludge bleed, spent wash water etc. These wastes are conventionally discharged into a natural stream polluting the receiving water course; affecting its characteristics and also the quality of the ground water.

With this background, studies were therefore conducted at the Kilpauk Water Works of Madras city where water is drawn from a shallow impounding reservoir. Raw water drawn from these have low turbidity ranging generally from 10 to 35 NTU excepting in periods of very low storage in lakes. Treatment of raw water is through conventional rapid gravity mechanical filters consisting of chemical dosage (alum 20 to 50 mg/l and chlorine 3 to 5 ppm), clariflocculators and rapid gravity mechanical filters. Washing of filters is done once in 24 hours by 3 minutes air scour with compressed air at 80 psi followed by backwash at 450 lpm per sq.m. for 7 minutes.

Sludge characteristics : Physical and chemical characteristics of sludges in this works were tested on 25 days between August and October 1994.

The sludge obtained from the clariflocculators was dark brownish in colour. It was an alum lime sludge. The PH of sludge varied from 6.50 to 7.80 with a mean of 7.2 thereby indicating alkalinity in general. The total solids varied from 4600 to 13460 with a mean of 9145 mg/l. The variation in the total solids concentration may be due to the sampling time. On some days samples were taken from the sludge wells before pumping of the sludge, i.e. after 3 to 4 hours settlement. Such samples would have less concentration of total solids. On some days the samples were taken after pumping of the sludge from the wells. These samples were taken from the bottom of the sludge well, which was more concentrated. The suspended solids in the clarifier varied over a range of 3988 to 13036 mg/l with a mean of 9006.

As a contrast the pH of filter backwash water ranged from 6.7 to 7.8 whereas total solids had a range of 420 to 2436 with a mean of 1153 mg/l. Corresponding figures for suspended solids were 252 to 2280 with a mean of 923 mg/l.

Conditioning : One of the main objectives of use of a centrifuge for conditioning of sludge is to minimise the sludge volume so as to reduce the area/space required for sludge drain.

Studies were carried out with a laboratory centrifuge to optimise on three variables (i) speed (ii) time of operation and (iii) dosage of chemicals/polyelectrolytes.

To start with, each of the above three variables was tested over a wide range and then followed by study over a narrower range. Thus detailed studies were carried out in the centrifuge with the following narrowed ranges.

Speed of centrifuge	: 1000 rpm, 2000 rpm, 3000 rpm
Time of operation	: 10 minutes, 20 minutes
Dosage of lime	: 100 mg/1, 200 mg/l, 300 mg/l
Dosage of polyelectrolyte (Zetag Magna Floc)	: 3 mg/l, 5 mg/l, 7 mg/l, 10 mg/l

Studies were also done without the use of lime/polyelectrolyte but for the speed/time of operation specified above. For all the above studies, consistency of the feed sludge was 12,428 mg/l.

The optimum range of operation for maximum sludge volume reduction was observed as below :

(i) 2000 rpm speed x 20 minutes if neither lime nor polyelectrolyte is added, volume reduction is 86%.

(ii) 2000 rpm speed x 20 minutes for 300 mg/l of lime dose, volume reduction is 92%.

(iii) 2000 rpm speed x 20 minutes for 7 mg/l of polyelectrolyte dose, volume reduction is 92%.

---

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** Asstt. Engineer, TWAD Board, Madras.

TABLE 1

Abstract of characteristics of waste water generated from Kilpauk water treatment plant

Sl. No.	Parameter	Raw water	Clarifier sludge				Backwash water	
			Sludge well 1	Sludge well 2	Sludge well 3	Composite sample	Filter unit 1	Filter unit 2
1.	pH	7.4 – 8.2 7.8	6.6 – 7.7 7.3	6.5 – 7.7 7.3	6.4 – 7.4 7.2	6.5 – 7.8 7.2	6.7 – 7.8 7.3	6.9 – 8.1 7.4
2.	Temperature °C	29.0 – 33.5[a] 30.0	29 – 33.5 30.0	29.5 – 32.0 30.0	29.0 – 31.0 30.0	29.0 – 32.0 30.0	29.0 – 31.5 30.0	29.0 – 31.5 30.0
3.	Conductance micromhos	318 – 370 344	395 – 657 486	376 – 470 423	336 – 660 427	431 – 535 475	347 – 415 373	340 – 480 369
4.	Total solids mg/l	196 – 492 323	1744 – 47908 14722	1520 – 11956 5666	724 – 26976 7845	4600 – 13460 9175	420 – 2436 1153	444 – 2144 841
5.	Dissolved solids mg/l	82 – 316 199	158 – 540 310	160 – 532 293	136 – 420 304	228 – 464 365	140 – 368 250	152 – 452 234
6.	Suspended solids mg/l	36 – 276 118	1520 – 47728 13827	1276 – 11732 5364	364 – 26680 7477	3988 – 13036 9006	252 – 2280 923	176 – 1944 573
7.	Non volatile solids mg/l	12 – 336 181	1340 – 37076 11115	1056 – 8608 3980	420 – 20316 4804	275 – 10100 6367	308 – 1656 791	228 – 1608 485
8.	Volatile solids mg/l	40 – 276 150	364 – 10832 3910	464 – 3540 1678	304 – 9280 2301	640 – 3700 2592	80 – 800 344	136 – 536 275

a : 29.0 - 33.5 Minimum – Maximum
33.0 Mean

The following results were also obtained.

(i) The centrate obtained by using polyelectrolyte had a turbidity of 3 NTU and dissolved solids 320 mg/l. The comparison of these values with the acceptable standards for drinking water (Turbidity — 2.5 NTU, total dissolved solids — 500 mg/l given in CPHEEO Manual) suggests that the centrate obtained by centrifuging the sludge with addition of polyelectrolyte may even be considered for drinking purposes without further treatment, after disinfecting.

(ii) The centrate obtained by adding lime has the characteristics : Turbidity — II NTU, Total dissolved solids — 330 mg/l. The centrate obtained without addition of lime/polyelectrolyte exhibits the values; Turbidity — 23 NTU, total dissolved solids — 270 mg/l. Both these will require marginal treatment, before being considered for drinking purposes.

(iii) The market rates of lime and polyelectrolyte are respectively Rs.4 and Rs.200/kg (1 : 50 ratio) whereas the optimum dosages are 7 mg/l and 300 mg/l (1 : 43 ratio). Hence the relative costs of polyelectrolyte and lime have only a marginal difference.

(iv) The optimum dosage of polyeletrolyte is 7 mg/l or equivalent to Rs.1.40 per kilolitre of water at the market rate of Rs.200/kg. As a contrast the cost of chemicals for conventional water treatment is 7.2 paise per kilolitre (Alum 22 mg/l at Rs.2.0/kg and lime 7 mg/l at Rs.4.0/kg) Thus use of chemicals for conditioning before centrifuging at 20 times the conventional treatment cost results in centrate quantity increasing from 86% to 92% i.e. 6% only.

Thus for a favourable benefit cost, centrifuging without chemical addition is more advantageous than centrifuging with chemical conditioning.

Conclusion :

The study indicated that centrifuging as a method of conditioning clarifier bleed and wash water from filters at water treatment plants can be a positive step towards the objective of clean and safe environment and water conservation.

Acknowledgement :

The authors are thankful to the Madras Metropolitan Water Supply and Sewerage Board for data collection, laboratory facilities and for permission to publish this paper.

References :

1. P. B. Nagarnaik and S. M. Dhabadgaonkar (1985), 'Backwash Waste Water', Jour. IWWA, January-March, Vol. XVI No. 1.
2. N. Rasheed Ahmed and K. Malay Chandhuri (1988) 'Characteristics of filter backwash water', Jour. IWWA, October-December, 1998, Vol. XX No. 1.
3. R. K. Sahu and G. V. Manel (1981), 'Reuse of backwash water in Telco Town, Jamshedpur', Jour. IWWA, July-September, 1981, Vol. XIII No. 3.

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Single Step Solution for Three-Reservoir Problem

S. L. Atmapoojya*, M. Tech., M.IWWA

Abstract :

In general the problem of three reservoirs is analysed by trial and error method either by assuming the nodal hydraulic gradient level (HGL) value of the junction(J) or by assuming the initial values of discharges through the pipes. Few authors[1,2] have given a direct solution for this type of problem. Here a single step and a unique solution is given i.e. the solution is obtained only by a single expression irrespective of direction of flow in the intermediate pipe. This has been explained by an illustrative example at the end of the paper.

Introduction :

The problem of three reservoirs is generally met in water distribution systems. It is also an example of branching of pipes. In the problem, three reservoirs are interconnected by three pipes with a common junction. This is diagrammatically shown in Fig. 1.

The analysis consists of determination of discharges and their direction through the pipes, the length of pipes, roughness characteristics, diameters are known.

This problem is considered as a special type of problem for under-graduate students, hence the solution can be helpful.

Equations used :

(i) Continuity equation at the junction which is converted in head equations.

(ii) Energy equation.

(iii) Head loss equation — Head loss through the pipes is given by Darcy Weisback equation —

$$h_f = rQ^2$$

In which h_f is the head loss through the pipe.

Q is the discharge through the pipe

r is the pipe resistance constant for the pipe, and given by

$$r = \frac{8fL}{\Pi^2 g\ D^5}$$

Where f = frictional factor,
L = length of pipe,
D = diameter of pipe.

Analysis :

The analysis of the problem is done in two parts —

(i) *Fixing the direction of flow through pipes :*

(a) The direction of flow will be from the highest reservoir i.e. from reservoir (1) to the junction (J).

(b) The direction of flow will be from junction (J) to the lowest HGL reservoir i.e. from junction to reservoir (3).

(c) The direction of flow for the intermediate reservoir (2) is decided by comparing the HGL of the reservoir and the weighted average of HGL values of all the reservoirs. The weighted average HGL value is given by —

$$H_{ave} = \frac{(H_1/r_1) + (H_2/r_2) + (H_3/r_3)}{(1/r_1) + (1/r_2) + (1/r_3)} \quad \text{.......... (1)}$$

Where H_1, H_2, H_3 are the HGL vales of reservoirs (1), (2) and (3) respectively. r_1, r_2 and r_3 are the resistance constants of pipes 1, 2 and 3 respectively.

There will be flow from junction to the reservoir (2), if H_{ave} is greater than H_2. And there will be flow from reservoir (2) to the junction, if H_{ave} is less than H_2. There will be no flow between reservoir (2) and junction, if H_{ave} is equal to H_2.

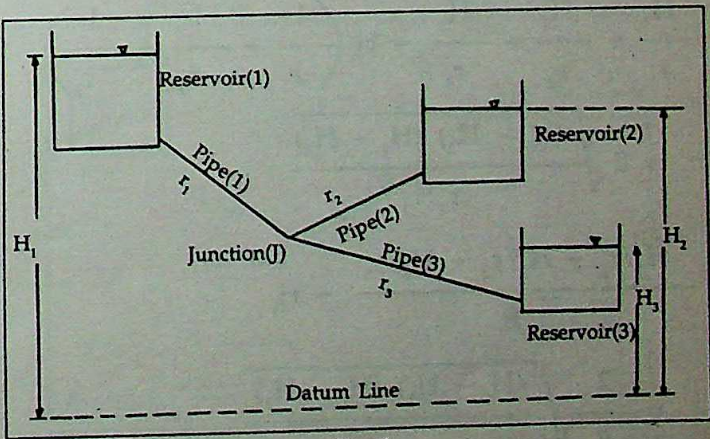

Fig. 1
The problem of three-reservoir

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(ii) *Analysis of flow* :

After fixing the direction of flow, continuity equation can be written at the junction. There are two cases for possible flow.

CASE (A) :

Direction in pipe (2) is from junction to reservoir (2) i.e. $H_{ave} > H_2$. Hence the continuity equation will be

$$Q_1 = Q_2 + Q_3 \quad \dots (2)$$

Where Q_1 = discharge through pipe 1,

$= [(H_1 - H_j)/r_1]^{1/2}$

Q_2 = discharge through pipe 2,

$= [(H_j - H_2)/r_2]^{1/2}$

Q_3 = discharge through pipe 3,

$= [(H_j - H_3)/r_3]^{1/2}$

Hence equation (2) can be written as

$$[(H_1 - H_j)/r_1]^{1/2} = [(H_j - H_2)/r_2]^{1/2} + [(H_j - H_3)/r_3]^{1/2} \quad (3)$$

Now using,

$$K_1 = \frac{H_1}{H_{ave}}, \quad K_2 = \frac{H_2}{H_{ave}}, \quad K_3 = \frac{H_3}{H_{ave}}$$

$$\text{And } K_j = \frac{H_j}{H_{ave}}$$

Equation (3) can be solved as,

$$\frac{H_1}{r_1} - \frac{H_j}{r_1} = \frac{H_j}{r_2} - \frac{H_2}{r_2} + \frac{H_j}{r_3} - \frac{H_3}{r_3} + 2\sqrt{\frac{(H_j - H_2)\,(H_j - H_3)}{r_2\,r_3}}$$

or

$$\frac{H_1}{r_1} + \frac{H_2}{r_2} + \frac{H_3}{r_3} - H_j\left(\frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3}\right) = 2\sqrt{\frac{(H_j - H_2)\,(H_j - H_3)}{r_2\,r_3}}$$

$$\frac{H_1/r_1 + H_2/r_2 + H_3/r_3}{R} - H_j = \frac{2}{R}\sqrt{\frac{(H_j - H_2)\,(H_j - H_3)}{r_2\,r_3}}$$

or

$$(H_{ave} - H_j)^2 = (4/r_2r_3R^2)\,(H_j - H_2)\,(H_j - H_3)$$

Where $R = (1/r_1) + (1/r_2) + (1/r_3)$

or, $H^2_{ave}(1 - K_j)^2 = K(K_j - K_2)\,(K_j - K_3)H^2_{ave}$

or, $(1 - K_j)^2 = K(K_j - K_2)\,(K_j - K_3)$

Where, $K = 4/(r_2r_3R^2)$

or, $1 + K^2_j - 2K_j = K\,[K^2_j - K_jK_3 - K_jK_2 + K_2K_3]$

or, $1 + K^2_j - 2K_j = KK^2_j - KK_jK_3 - KK_jK_2 + KK_2K_3$

or, $(1 - K)K^2_j - [2 - K(K_2 + K_3)]K_j + 1 - KK_2K_3 = 0$

By solving the above quadratic equation for K_j and simplifying,

$$K_j = \frac{[2 - K(K_2 + K_3)]}{2(1 - K)} \pm \frac{K(K_2 - K_3)}{2(1 - K)}\sqrt{1 + \frac{4(1 - K_2)\,(1 - K_3)}{K(K_2 - K_3)^2}} \quad \dots (4)$$

When direction of flow is from junction to the reservoir(2), value of H_j will be less than H_{ave}, hence considering negative sign in equation (4). Hence

$$K_j = \frac{[2 - K(K_2 + K_3)]}{2(1 - K)} - \frac{K(K_2 - K_3)}{2(1 - K)}\sqrt{1 + \frac{4(1 - K_2)\,(1 - K_3)}{K(K_2 - K_3)^2}} \quad \dots (5)$$

CASE (B) :

Direction of flow in pipe (2) is from reservoir (2) to junction i.e. $H_{ave} < H_2$, and continuity equation will be,

$$Q_1 = Q_3 - Q_2 \quad \dots (6)$$

Similar to equation (2) equation (6) can be written as

$$[(H_1 - H_j)/r_1]^{1/2} = [(H_j - H_2)/r_2]^{1/2} + [(H_j - H_3)/r_3]^{1/2}$$

Using same analogy and solving for K_j

$$K_j = \frac{[2 + K(K_2 + K_3)]}{2(1 + K)} + \frac{K(K_2 - K_3)}{2(1 + K)}\sqrt{1 + \frac{4(1 - K_2)\,(1 - K_3)}{K(K_2 - K_3)^2}} \quad \dots (7)$$

Equations (5) and (7) are similar except for the sign. Both the equations can be written in a similar form by using a factor 'd', which is named as direction factor,

$$K_j = \frac{[2 + Kd(K_2 + K_3)]}{2(1 + Kd)} + \frac{Kd(K_2 - K_3)}{2(1 + Kd)}\sqrt{1 + \frac{4(1 - K_2)(1 - K_3)}{Kd(K_2 - K_3)^2}} \quad \dots (8)$$

When $H_{ave} > H_2$, valve of $K_2 < 1$, value of factor 'd' is taken as (–1).

When $H_{ave} < H_2$, value of $K_2 > 1$, value of factor 'd' is taken as (+1).

When $H_{ave} = H_2$, value of $K_2 = 1$, value of factor 'd' is taken as zero.

Hence equation (8) can be used in any condition. Now HGL value of junction, H_j can be

$$H_j = K_j * H_{ave} \quad \dots (9)$$

After knowing value of H_j, flow through different pipes can be calculated easily according to their HGL values.

$$Q_1 = [(H_1 - H_j)/r_1]^{1/2}$$

$$Q_3 = [(H_j - H_3)/r_3]^{1/2}$$

And $$Q_2 = [(H_j - H_2)/r_2]^{1/2}$$

And continuity equation should be checked.

Illustrative Example :

The problem as shown in fig. (2) is to be analysed. The data are given in the figure.

Solution — Direction of flow in pipe(2) will be decided as per the weighted average of the HGL values,

$$H_{ave} = \frac{(H_1/r_1) + (H_2/r_2) + (H_3/r_3)}{(1/r_1) + (1/r_2) + (1/r_3)}$$

$$= \frac{(70/20) + (40/15) + (20/18)}{(1/20) + (1/15) + (1/18)}$$

$$= 42.258 \text{ m} > 40.000 \text{ m}$$

Since $H_{ave} > H_2$, hence direction of flow will be from junction to reservoir(2).

$$K_1 = \frac{H_1}{H_{ave}} = \frac{70}{42.258} = 1.6565$$

$$K_2 = \frac{H2}{H_{ave}} = \frac{40}{42.258} = 0.9466$$

$$K_3 = \frac{H_3}{H_{ave}} = \frac{20}{42.258} = 0.4733$$

Here value of K_2 is less than 1, hence value factor 'd' will be (–1).

$$R = (1/r_1) + (1/r_2) + (1/r_3) = 0.1722$$

$$K = 4/(r_2 r_3 R^2) = 4/[15 * 18 * (0.1722)^2] = 0.4995$$

Using equation for K_j with 'd' equal to (–1)

$$K_j = \frac{[2 - K(K_2 + K_3)]}{2(1 - K)} - \frac{K(K_2 - K_3)}{2(1 - K)}\sqrt{1 + \frac{4(1 - K_2)(1 - K_3)}{K(K_2 - K_3)^2}}$$

$$Kj = \frac{[2 - 0.4995(0.9466 + 0.4733)]}{2(1 - 0.4995)} - \frac{0.4995(.9466 - .4733)}{2(1 - 0.4995)} \sqrt{1 + \frac{4 * .0534 * .5207}{0.4995(0.4733)^2}}$$

or, $K_j = 1.2895 — 0.3344 = 0.9551$

Hence, $H_j = 0.9551 * 42.258 = 40.3577$

Now $Q_1 = [(70 - 40.3577)/20]^{1/2} = 1.217$ units

$Q_2 = [(40.3577 - 40)/15]^{1/2} = 0.154$ units

$Q_3 = [(40.3577 - 20)/18]^{1/2} = 1.063$ units

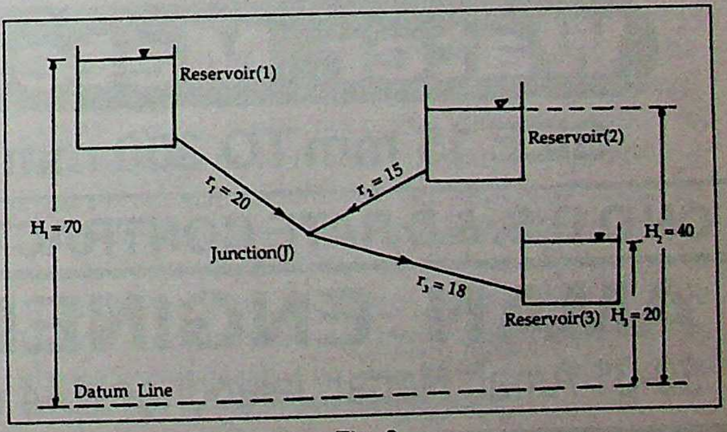


Fig. 2
Illustrative Example

Checking continuity equation,

$Q_1 = Q_2 + Q_3$

or, $1.217 = 0.154 + 1.063$ i.e. ok.

Conclusions :

In the methodology only one expression is used for any condition of flow, by simply taking the direction factor into account. The method is very simple and quick. Within less number of step calculations, the final solution can be achieved. If the method is compared with other methods it takes less time than other methods. There is a relationship between K_j and K_2 i.e. when K_2 is less than one, K_j is also less than one, and vice versa. But the relationship is not generalised, which will universally hold good for any type of problem. The Author is trying to establish some empirical expression for H_j or K_j in terms of known parameters, so that such type of problems can be solved very easily. If the expression is obtained, it will be given later.

References :

(i) S. Sathuraman and K. G. Rangaraju — 'Direct Solution of Three Reservoir Problem' Civil Engineering, Journal. Vol. 11, April, 1969, Paper No. CE 143.

(ii) Raghvendra Singh — 'Direct solution of Three Reservoir Problem' Journal of Inst. of Engrs. (India), Civil Engineering division, Vol. 62, March 1982.

(iii) R. J. Garde and A. G. Mirajgaoker — 'Engineering Fluid Mechanics'. Nemchand and Bros. Roorkee.

(iv) S. L. Atmapoojya — 'Distribution of flow in a branching system of pipes with N-numbers of branches'. Proc. of All India Seminar on Hydraulic Engineering. 27-28 Jan., 1996, IE(I), Nagpur.

(*Appendix — Notations*)

D = Diameter of pipes

D_1, D_2, D_3 = Diameter of pipes 1, 2 and 3.

d = Direction factor

f = Frictional factor

H_1, H_2, H_3 = GHL values of reservoirs 1, 2 and 3.

H_{ave} = Weighted average of HGL values.

H_j = HGL value of junction J

K = $4/(r_2 r_3 R^2)$.

K_1, K_2, K_3 = Ratios of HGL values.

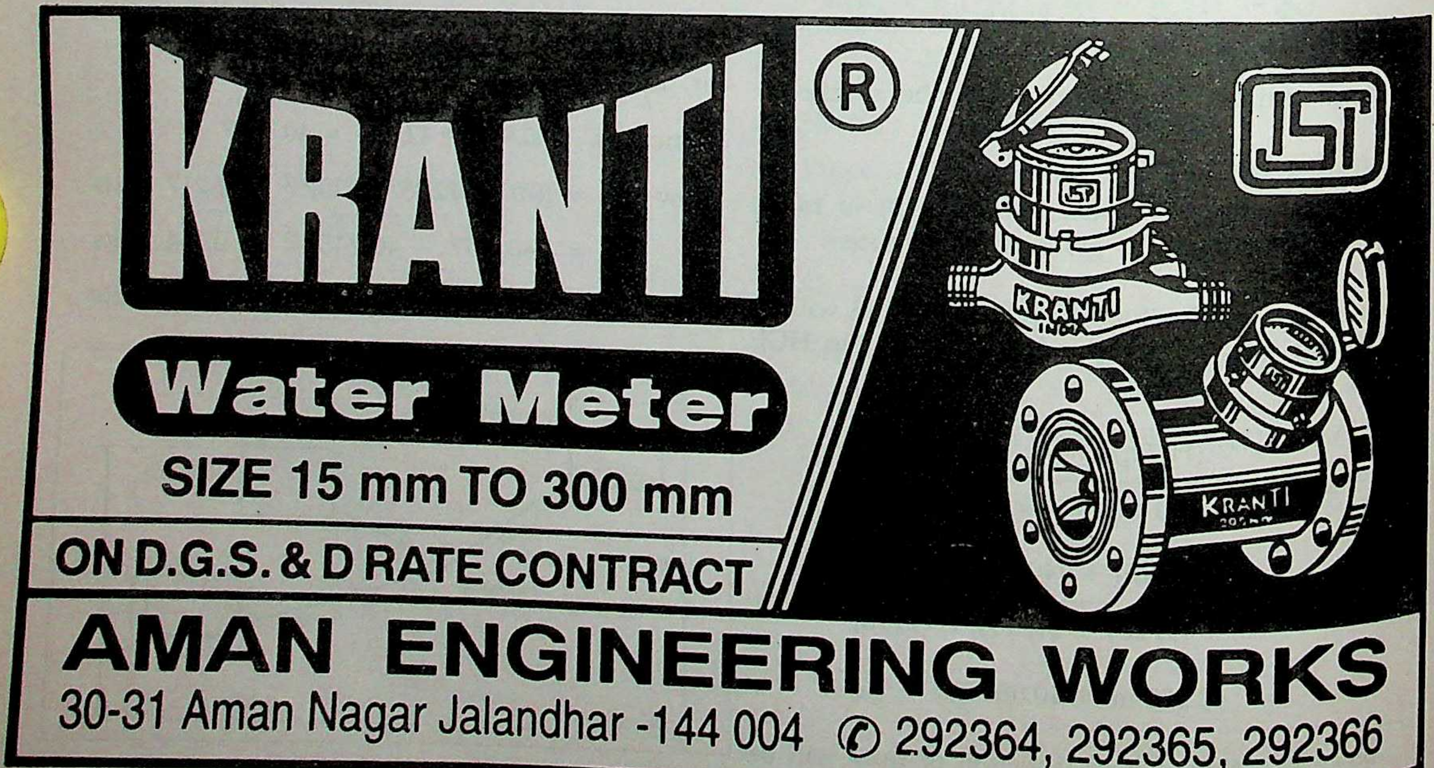
L_1, L_2, L_3 = Length of pipes 1, 2 and 3.

Q_1, Q_2, Q_3 = Discharges through pipes 1, 2 and 3

R = $(1/r_1) + (1/r_2) + (1/r_3)$

r_1, r_2, r_3 = Pipe resistance constants for pipes 1, 2 and 3.

* * *



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Water Quality Monitoring — A Case Study

A. G. Sirkar*, Ms. Amita Bhatnagar** and Ms. Manju Khanna**

Introduction :

Water available for human consumption is only 3% of the total quantity of water present on the Earth. This small pool is now under great pressure, owing to a tremendous increase in domestic, agricultural and industrial demands. On the other hand, there has also been an increase in the awareness regarding the quality of water to be consumed. In this context, a study recently completed by the Authors on water quality in a mid east Asian country, which provides some thought-provoking material for both the policy makers and the water engineers in our country.

The objectives of the study were to locate all the ground water sources utilized by the concerned ministry of the country to supply drinking water to the public, to identify tankers contracted to convey this water, to collect samples of water from these sources and to carry out physical, chemical and bacteriological tests on these samples, to subsequently analyze the test results, and based on the analysis, to recommend measures to improve ground water and tanker supply quality, including strategies for enhancing people's awareness of the importance of clean drinking water, and of protecting the underground water sources against contamination.

Background :

The geographical location of the project country is such that it has a long coast line. Topographically, the country consists of northern hills, alluvial coastal plains, a gently sloping plain located at the foot-hills and a large area in the interior covered by sand dunes. The climate is hot and dry in the summers, and cool and wet in the winters.

The main sources of water are Wells and Wadis (small seasonal rivers). The water supply, according to a royal decree, is the government's responsibility. There is no piped water supply. The government supplies water to the consumers by means of tankers, both government owned and private. The sewerage system consists of septic tanks for individual units, from where the septage flows into community holding tanks. Government operated tankers remove the septage from these holding tanks by suction and transport them to sewage treatment plants or unlined dumping yards, the latter case being more frequent.

Collection of samples :

Samples were collected region-wise (region being the equivalent of a state in India) 3.0 litres of sample was collected from each source as follows :

(a) 1500 ml for physico-chemical tests.

(b) 500 ml in a sterilized bottle for bacteriological tests.

(c) 250 ml for tests for Mercury.

(d) 250ml for tests for Phenolic Compounds and Cyanide.

(e) 250ml for tests for Selenium.

In collection and transportation of samples, guidelines given in local standards, relevant British Codes and the AWWA publication 'Standard Methods of Testing Water and Waste Water' were followed. Necessary preservatives were added during transportion of the samples to the testing laboratories. In addition, the samples were refrigerated in Coleman Insulated Containers.

Concomitant with the sample collection, data on well and tanker condition and well surroundings was also gathered, to identify the possible sources of pollution. This data, recorded in a standard format by trained personnel collecting samples, included information pertaining to the ground slope at the location of the well, surface protection provided for it, presence/absence of garbage dumps, drains, septic tanks near the well, possibility of contamination of well water by cattle, vegetation or bird excrement and finally the type and condition of the cover to the well. Three photographs of each source were taken to record the general conditions of hygiene around the source. More than 1.10 lakhs kilometer road travel was required to collect around 800 samples. Helicopter was used for collection of samples in a few remote locations.

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** Co-authors (STUP Consultants Ltd.)

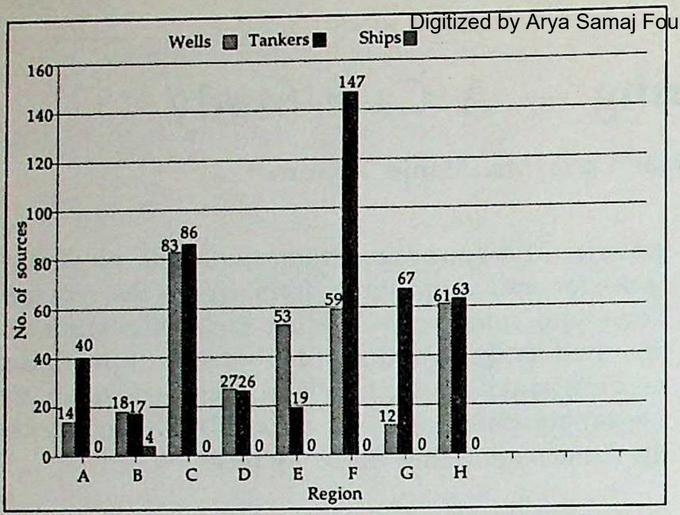

Fig. 1

Break-up of the water sources utilized by the Ministry

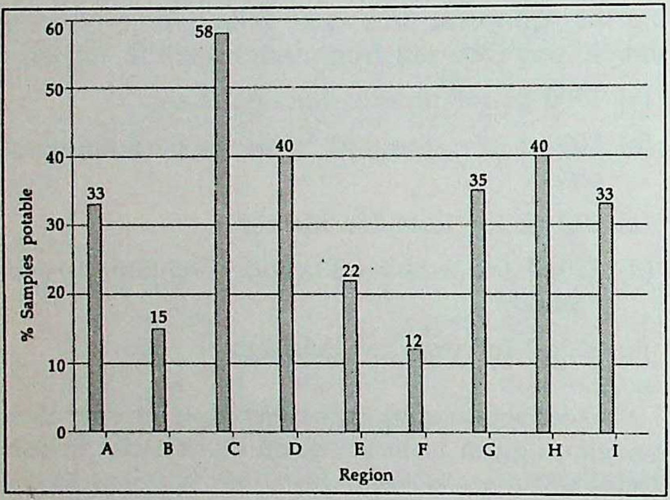

Fig. 3

Results Region wise

Sample testing :

25 Physico-Chemical and Bacteriological tests were performed on each sample. The tests were done in two of the local Ministry's laboratories located in the capital of the country. The tests, decided after consultation with the client, were —

(a) Physico-Chemical — Colour, odour, pH, turbidity, taste, conductivity, total dissolved solids, Ammonia, Nitrites, Nitrates, Chlorides, total Alkalinity, Calcium, Sulphates, Iron, Magnesium, Manganese, Fluorides and total Hardness.

(b) Toxic Chemicals — Cyanide, Selenium, Phenolic Compounds and Mercury.

(c) Bacteriological — Total Coliforms, E.Coli.

Some more tests listed in local standard/recommended by the consultant, were not performed due to non-availability of testing facilities.

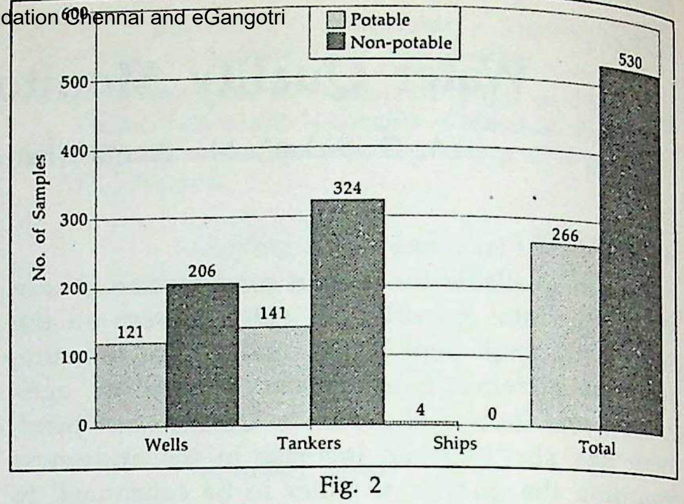

Fig. 2

Results for the entire country

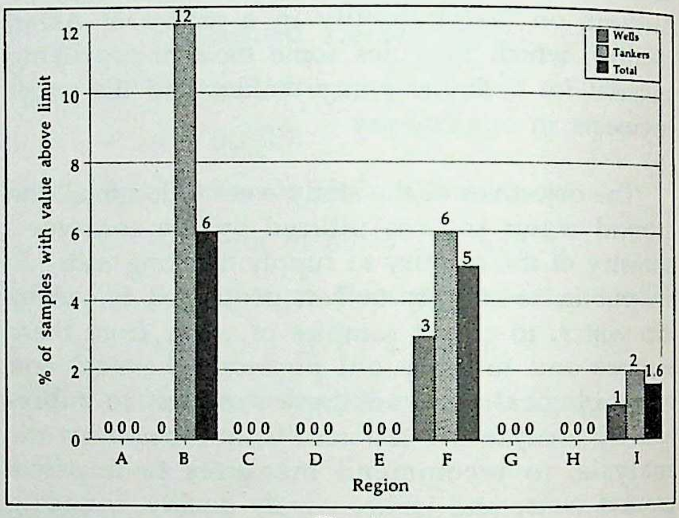

Fig. 4

(for Selenium)

Results :

The break-up of the various sources utilized by the ministry to supply drinking water is shown in Fig. 1, region wise.

The test results for these sources were compared with the local standards, and if the value of any one parameter tested exceeded the higher limit prescribed for it in the local standard, the sample was categorized as non-potable. These results are shown in Figs. (2) and (3).

The standards used for analysis of test results are given in a table on page 218.

The final result for the entire country was as follows.

In Fig. 3, A – H represent the regions and I the country as a whole.

% of samples polluted with Selenium, Cyanide,

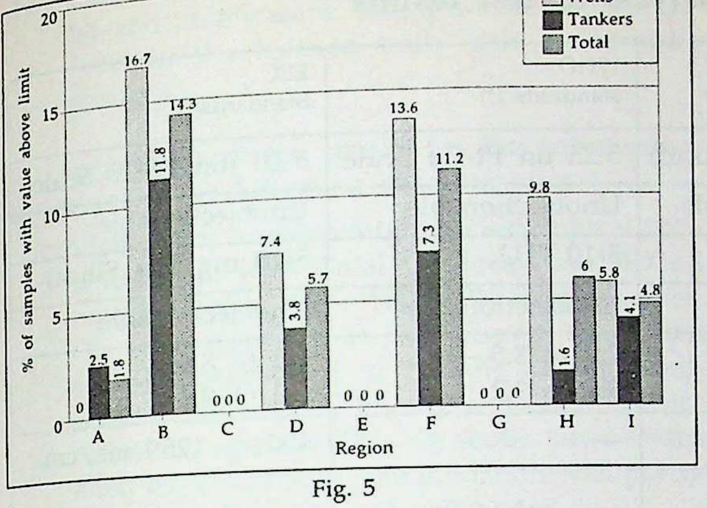

Fig. 5
(for Cyanides)

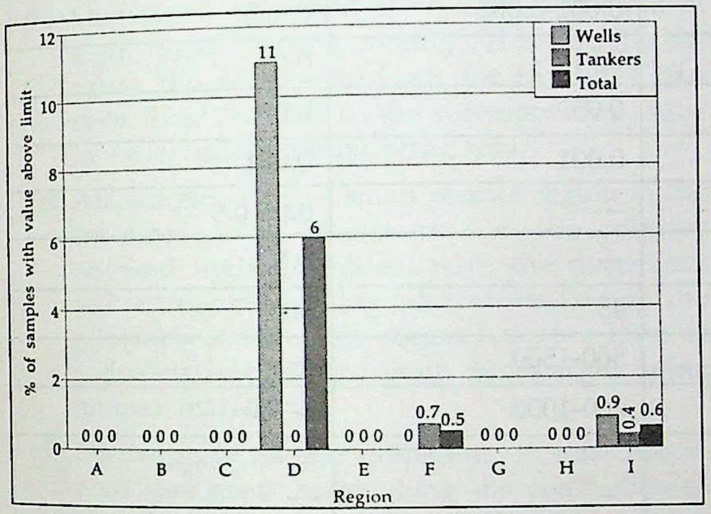

Fig. 6
(for Phenolic Compounds)

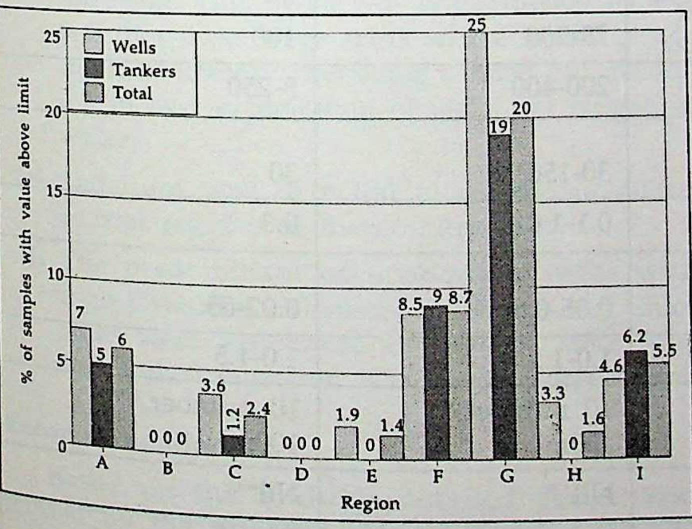

Fig. 7
(for Chlorides)

Phenolic Compounds, Chlorides, Fluorides and Bacteriological Parameters (total Coliform and E.Coli) were plotted. These graphs are presented in figures 4 to 9.

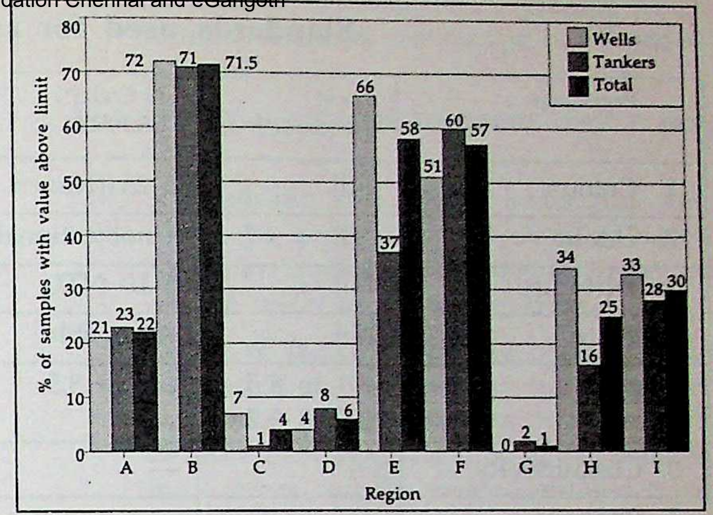

Fig. 8
(for Fluorides)

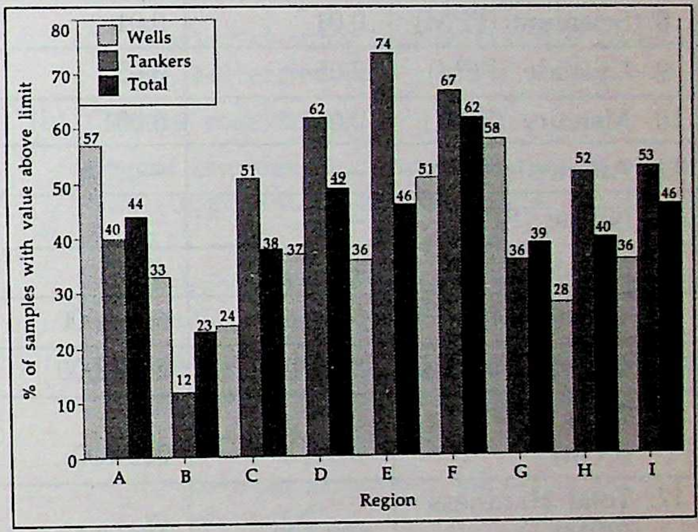

Fig. 9
(for Bacteriological Parameters)

The harmful effects of these elements were highlighted in the study report. Some of these are listed below :

(i) **Bacteriological contamination** : Causes diseases like diarrhoea, jaundice, cholera, amoebic dysentery.

(ii) **Selenium** — is a known carcinogen and also causes dental caries.

(iii) **Cyanides** especially organic Cyanides are highly toxic and in high doses can be fatal.

(iv) the presence of even trace amounts of **Phenolic Compounds** can impart objectionable taste to water following chlorination. In addition, chlorophenols are carcinogenic.

(v) excess of **Fluorides** can cause mottling and chipping of teeth, especially in children, and also dental fluorosis.

Standards used for analysis of test results

Parameter	Local standard(*)	IS Code(*) (IS:10500)	WHO standards (*)	EEC Standards(*)
1. Colour	Nil	5-25 (Hazen unit)	5.25 on Pt-Co Scale	5-20 (on Pt-Co Scale
2. Odour	Nil	Unobjectionable	Unobjectionable	Unobjectionable
3. Turbidity	Nil	5-10 NTU	5-10 JTU	5-10 mg/l(as Silica)
4. Taste	Nil	Agreeable	Unobjectionable	Unobjectionable
5. pH	7.0 to 8.5 — 6.5 to 9.2	6.5 to 8.5	7.0 to 8.5 — 6.5 to 9.2	6.5 to 8.5 — 6.0 to 9.5
6. Conductivity	—	—	—	400 — 1250 ms/cm.
7. Phenolic Compounds (PPM)	0.001-0.002	0.001-0.002	0.001-0.002	0.005
8. Selenium (PPM)	0.01	0.01	0.01	0.01
9. Cyanide (PPM)	0.05	0.05	0.05	0.05
10. Mercury (PPM)	0.001	0.001	0.001	0.001
11. Ammonia (PPM)	—	—	—	0.05-0.5
12. Nitrite (PPM)	—	—	—	0.10
13. Nitrate (PPM)	45	45	45	50
14. TDS (PPM)	500-1500	500-2000	500-1500	—
15. Chlorides (PPM)	200-600	250-1000	200-1000	5-200
16. Total Alkalinity (PPM)	—	200-600	—	—
17. Total Hardness (PPM)	100-500	300-600	200-600	—
18. Calcium (PPM)	75-200	75-200	75-200	100
19. Sulphate (PPM)	200-400	200-400	200-400	5-250
20. Magnesium (PPM)	30-150****	—	30-150**	30
21. Iron (PPM)	0.1-1.0	0.3-1.0	0.1-1.0	0.3
22. Manganese (PPM)	0.05-0.5	0.1-0.3	0.05-0.5	0.02-05
23. Fluorides (PPM)	0.8	1.0-1.5	1.0-1.5	1.0-1.5
24. Total Coliform	10 number/ 100 ml.	10 number/ 100ml	10 number/ 100ml	10 number/ 100ml
25. E.Coli	Nil	Nil	Nil	Nil***

* Values indicate maximum acceptable value or desirable/recommended value — maximum acceptable value.

** If there are 250 mg/l of sulphates, Mg content can be increased to a maximum of 125 mg/l with the reduction of sulphates at the rate of 1 unit for every 2.5 units of Sulphates.

*** Value for Faecal Coli. **** If Sulphates < 250 mg/l, this limit is 150 mg/l.

Note : The limits for Total Coliforms are for any one sample, 95% of the samples examined throughout the year should not contain any coliform organisms in 100 ml.

(vi) **Chlorides** impart an objectionable taste to water and at the same time produce adverse effects in the human body due to osmotic changes.

An analysis of the results for the entire country revealed the following characteristics;

(a) Well water showed high bacteriological contamination, with Total Coliforms and E.Coli reported being above 180 MPN in some cases. On investigation, it was found that such samples originated in regions having inadequate sanitation facilities. Due to the presence of leaking and overflowing septic tanks in the area, bacteriological contamination was percolating down to the sub-soil water.

(b) Fluorides were found to be high in five out of eight regions of the country. This may be because the acceptable limit for fluorides had been fixed lower than the corresponding value in other international standards.

(c) All samples from a small remote region in the interior of the desert area in the country showed high Cyanides, with the maximum value reported being almost ten times the allowable value. This region has zero level of industrialization, the main occupation being animal rearing.

(d) On mapping of the pollutants, it was discovered that some areas along the coast showed very high concentration of Chlorides — believed to be a possible evidence of sea water intrusion. This belief was strengthened by the fact that these were areas where intensive agriculture activity was being carried out, resulting in over-exploitation of wells (for irrigation water).

(e) Selenium was detected along the northern coastal regions of the country only.

(f) The predominant occupations in areas with high Cyanides, Selenium, Sulphates and Chlorides were agriculture and sheep/camel rearing. Industrialization was almost non-existent.

Recommendations :

Based on the findings detailed above, and guided by the project's objectives, the following recommendations were put forward.

(i) *Preventive measures :*

(a) Prevention of contamination of underground water reserves be given the same, if not higher; priority as implementation of treatment schemes for the defective water.

(b) Sustainable exploitation of ground water sources should be carried out, in a planned manner.

(c) Industrial effluents be treated before discharge.

(d) Surrounding area of the wells and well covers be kept clear and clean to avoid contamination. This is particularly relevant for the wells in low lying areas.

(e) Repair of faulty septic and holding tanks be carried out to prevent subsoil water pollution. Piped sewerage and sewage/effluent treatment schemes to be initiated in all areas and the treated effluent to be reused/disposed safely.

(f) Solid waste management programmes be undertaken.

(g) Regular cleaning and disinfection of tankers be carried out.

(ii) *Curative measures :*

Urgent implementation of curative measures was suggested. These measures would include :

(a) Disinfection of water (to be given top priority).

(b) Design of treatment schemes area-wise, specific to the pollutants in the area.

(c) Establishing regional laboratories in order to monitor, at regular intervals, the quality of water.

(d) Random sampling, testing and analysis of results in different regions annually through dedicated quality control cell which was to be formed specifically for this purpose.

(e) Review of annual reports pertaining to incidents of water borne diseases in different regions.

(iii) *Greater emphasis be laid on routine monitoring of water sources, in the following manner :*

(a) Testing of well/tanker samples at source using portable kits, and in the laboratories, at pre-decided intervals (following WHO guidelines).

(b) Initiation of intensive regional studies, to further the objectives of the present study. The further studies would be with an increased frequency of sampling and number of samples per source — to enhance accuracy and statistical reliability of the data collected.

(iv) *Regular monitoring of tankers conveying water was also suggested, with the following policy changes recommended :*

(a) Licences be issued on the following terms :

(i) Potable water be carried by licensed tankers only.

(ii) Owners to operate only licensed and inspected tankers.

(b) Tankers be cleaned and disinfected at stipulated periods — Centralized cleaning and disinfecting facility be organised by the Ministry to ensure complete control over the process.

(c) Regular monitoring of the difference between the quality of water being received by the tanker, and that being delivered by it, be carried out.

(d) Violatation of conditions of issue of licence by tanker owners be made liable for punishment.

(v) *Recommendations were also made for initiation of some programmes to raise the general public's awareness of importance of clean drinking water, as per the requirements of the project. The programmes were to consist of disseminating information on :*

(i) Sources of pollution of well/tanker water.

(ii) Measures for preventing this pollution.

(iii) Proper maintenance of septic/holding tanks.

(iv) Danger of epidemics (of diarrhoea, cholera, jaundice etc.) caused by consumption of contaminated water.

(v) Footage, from around the world, about diseases caused by contaminated water.

It was suggested that these programmes be carried out with the active involvement of the national media, international agencies like WHO/UNICEF, local authorities, religious heads, local health centres, non-governmental organisations etc; and the implementation procedures could involve printing information leaflets and messages on water tankers, government supported advertising in the media and introducing health awareness programmes in the school curricula etc.

Conclusion :

From these studies it can be concluded that it is necessary to test drinking water in our country for all the parameters listed in IS 10500/CPHEEO manual. At present, it is generally being tested for a very few of these parameters like turbidity, pH and testing of heavy metals is not taken up at all, because of the logistical difficulties involved, although there have been incidents like the Arsenic poisoning detected in well water in West-Bengal and the suspected metal poisoning case in Kanpur. Testing of toxic metals should be made mandatory atleast in industrialized areas, where untreated toxic industrial effluents are often discharged into unlined drains, and from there they seep into the ground and contaminate the sub-soil water. This study has shown that sub-soil water in non-industrialized regions can also have the presence of toxic metals, possibly due to contamination by soil strata. Thus it would be desirable to introduce heavy metal testing for all waters irrespective of the area characteristics and the source of the waters. It is heartening to note that West Bengal Govt. has recently taken up a project for removal of arsenic, costing Rs.750 crores for an affected area.

◆

OBITUARY

The Indian Water Works Association mourns the sad and sudden demise on 16th August 1996 at Mumbai, at the age 69, of Shri Devendra Ghosh, one of its life member and the Vice-Chairman of the Greater Mumbai Plumbers' Association. A graduate in Commerce of Delhi University, Shri Ghosh obtained his diploma in Civil & Sanitary Engineering from a Technical Institute at Madras and then worked on different construction projects for luxury type hotel buildings as well as residential complexes in the country and particularly in Mumbai. He then specialised in quality plumbing work and has carried it out in all types of buildings e.g., residential, commercial, institutional, industrial etc. Shri Ghosh was a silent, sincere and meticulous worker, who worshipped work as God. In his passing away, IWWA will be missing a pleasant personality who always used to attend its annual conventions and different seminars regularly. May his soul rest in peace.

Rural Water Supply in Hilly Areas of Jammu Region
Problems and Remedies

131035

B. K. Suri*

Synopsis :

Notwithstanding the achievement of 99% coverage in Jammu region, rural water supply schemes in Jammu are beset with numerous problems which have affected the efficacy of the schemes, which gets manifested at times in the form of deputations, dharnas and other agitational methods. The problems are further accentuated in summer months when the demand of water soars abnormally high and supplies get reduced owing to many factors. This paper aims at bringing out the maladies afflicting our rural water supply system despite the best efforts put in by the Public Health Engineering authorities/State Government, and possible remedies which can be tried.

Introduction :

Jammu & Kashmir which is the northern-most State has a total area of about 2,18,000 sq. kms. including the areas under the illegal occupation of Pakistan and China. From the geographical and climatical considerations, the State can be divided into three distinct regions, namely Jammu, Kashmir and Ladakh. While the average rainfall in Jammu and Kashmir regions is to the tune of 1150 mm and 750 mm respectively, Ladakh gets a very scanty rainfall which is even less than 100 mm. The three regions are further categorised by huge temperature variations. While the temperature in Jammu region which has plain to hilly terrain may range from 4°C in winter to 46°C in summer, in Kashmir which is generally hilly and located at over 5000 ft. above M.S.L., temperature varies from – 15°C in winter to + 15°C. However, desert-like conditions prevail in Ladakh where winter temperature drops to as low as – 45°C.

Against this back-drop of topography and temperature variations, implementation of rural water supply schemes had been rather slow in all the three regions of the State till 1976. However, with the launching of centrally sponsored Accelerated Rural Water Supply Programme (ARWSP) in 1977-78, rural water supply got a fillip and several new schemes for rural areas were formulated, got approved by Central Public Health and Environmental Engineering Organization (CPHEEO) and subsequently taken up for execution in a phased manner as per availability of funds. Even in the State Sector, rural water supply received a fair degree of priority and it was endeavoured to complete maximum number of schemes by way of higher allocations.

Present status of Rural Water Supply :

Restricting to Jammu region alone, 3396 villages have already been brought within the ambit of organised rural water supply programme ending March, 1995. As the total number of villages in Jammu Province stands at 3616 out of which 195 villages are uninhabited, a coverage to the extent of 99% has already been achieved in Jammu region. Reportedly, the remaining 25 villages are targeted for coverage during the financial years 1995-96 and 1996-97.

Some of the main problems which have greatly impaired the efficiency of rural water supply schemes in Jammu Region/J&K State are discussed below along with the possible solutions to these.

I. Public health engineering norms :

(i) *Design period :*

Rural water supply schemes envisaged and executed under centrally sponsored A.R.W.S.P. were originally designed for a period of 15 years @ 40 lpcd which was the stipulated norm fixed by C.P.H.E.E.O. But now many of the completed and commissioned schemes have outlived their designed period resulting in supply level of less than 40 lpcd and leading to discontent among the rural people. Besides, some other water supply schemes executed under Minimum Needs Programme though designed for a service level of 70 lpcd for a period of about 20 years and functioning for the last 15 years or so, have become problematic mainly on account of increase in population and corresponding reduction in per capita supply.

(ii) *Per capita supply :*

Existing norm of 40 lpcd visualised and adopted some 20 years back has been observed as grossly inadequate and irrelevant in the changed life scenario in the villages. This in no way fulfills the aspirations of the rural masses now.

It is imperative that the prevalent norms in respect of design period and per capita supply are reviewed and amended to cater to the increased water supply demand in the rural areas.

---

* Supdtg. Engineer (Retd.) P.H.E.D., Govt. of Jammu & Kashmir.

II. Change in life-style of people :

Several social developmental programmes aiming at improving the living conditions in the villages namely Illiteracy Eradication, Rural Water Supply, Rural Electrification, Health Care etc. in addition to many other poverty alleviation activities viz., Indira Awas Yojna, Jawahar Rozgar Yojna, lending facilities, improved seeds and fertilizers, Extension of Irrigation and several other Integrated Rural Development Programmes launched by the Government have given a tremendous boost to family income in the villages. As a sequel, there is a change in life style in the rural areas, and many villages are getting urbanised. Now, a sizeable number of houses have proper bath-rooms where daily washings are effected. Besides, sanitary toilets have been installed by affluent people in the villages. As a consequence, water supply demand in rural areas has soared pretty high both from quantitative and qualitative considerations. As rural water supply schemes have been designed to meet the barest minimum requirement of drinking, cooking and bathing @40 lpcd, now there is shortage of water leading to dis-satisfaction amongst the people covered under the Rural Water Supply Programme. More so, the distribution of water becomes uneven as the few rich people in the villages consume more than their share by dint of clout they wield in their respective areas.

III. Non-provision for the cattle population :

As per available records, India has a live-stock population of about 460 million which are mostly located in rural areas. As the villagers love their cattle and treat them like family members, the cattle particularly the milching ones are fed on tap water in problem villages with distant water sources. This adversely affects the supply position in the area. Just imagine, a buffalo or a jersey cow gulping about two buckets of water (40 ltrs) in one go only. As 40 ltr is daily per capita supply, a high cattle population may virtually lead to water famine in the village.

There have been embarrassing situations when village people were admonished on the issue and they shot back saying

(a) Have animals no life ?

(b) Your scheme is wrong

(c) We would first feed our cattle and then our family members etc. Admittedly, as per the ground realities, cattle demand is inseparable from the human demand in the villages. It transpires that the entire exercise of population projection, design and implementation of rural water supply projects would not yield the desired results unless cattle are provided for in rural water supply schemes.

IV. Power break-down and voltage fluctuations :

Ground water sources viz., deep bore tube wells and dug-wells comprise the main source of water in rural areas of Jammu and Kathua Districts. Besides, several schemes in Rajouri and Udhampur districts are dependent on dug-wells to serve as a source of supply. Water is lifted from these sources in single or multi-stage pumping, stored in ground service reservoirs and then supplied through a designed distribution system to a number of villages falling within the scope of the scheme.

It has invariably been noticed that the pumping gets adversely affected on account of power break-down, voltage fluctuations and low voltage conditions. More often than not, pumps are operated at much lower than the specified voltage lest there is a complete disruption of water supply in the catered areas. Obviously, the pumping machinery is subjected to a greater wear and tear and other recurring damages at low voltage conditions thus warranting repeated repairs of damaged machinery which is not feasible owing to limited budgetary resources.

The problem becomes all the more acute in summer season when the water demand far exceeds the supply levels and despite best co-ordination by the Electrical Department there is no respite to the low voltage conditions, our State being located at the tail-end of the northern grid.

Installation of voltage stabilizers has provided reprieve on some rural water supply schemes but then adequate funds are not available to provide stabilizers at each and every rural pumping station.

The issue of stable power which is a key to the success of a lift project is required to be perused in its proper perspective and remedial measures taken to ensure smooth and uninterrupted pumping at Water Supply Lift Stations.

V. Depletion of sources :

In the hilly areas of Jammu region, springs comprise the source of supply. However, behavioural pattern of some of the springs has been found to be highly unpredictable because of deforestation and resultant climatic changes. With the passage of time the discharge of some of the identified sources got dwindled while in some other cases, spring sources slided down on account of heavy land-slides in the remote hilly region. All this resulted in depletion of some of the sources thus restricting the scope of completed water supply schemes below the designed level.

It has also been noted that the discharge of some of the tube-wells gets depleted after a few years of commissioning. There have also been cases when the tube-wells started giving sand resulting in caving and subsequent abandonment of the tube-well. Since the cost of augmentation of the affected scheme by way of new tube-wells/alternative spring sources and other allied items would require large amounts which cannot be readily provided, the supply position in the covered area gets greatly jeopardised leading to discontent among the rural masses.

VI. Pipe alignment in the hilly areas :

Some of the operational problems in the hilly region mainly ensue from long gravity mains/rising mains/distribution mains laid common for several villages from economical consideration. As the pipes are aligned for considerable length through undulating hilly terrain, these are prone to damage. Besides, it is not feasible to embed the pipes in trenches throughout the entire alignment on account of rocky terrain, more so, as blasting is not permissible for proper trenching in several areas from security considerations. Resultantly, these mains are vulnerable to damage in exposed stretches by the people residing enroute who deliberately puncture the pipes or loosen the joints for a handy and hefty water supply. As a sequel, the efficacy of the entire system gets greatly impaired resulting in shortage of water. Obviously, conducting recurring repairs in remote areas entails considerable delay. Besides, inadequacy of maintenance, funds is a big handicap for timely repairs.

For an uninterrupted water supply, it is considered imperative that remedial measures to check the frequent damages by the people are taken promptly. These measures may be in the form of

(i) placing the Public Health Engineers with magisterial powers

(ii) prompt action by District administration to haul up and punish the guilty whenever such cases are referred to them.

VII. Operational problems :

The operational problems stem from a multiplicity of reasons which may be briefed as under :

(i) Lengthy gravity mains/distribution mains. Issue already discussed in Para VI above.

(ii) Highly inadequate maintenance and repair allocations. These in no way suffice for recurring repairs of pipes and pumping system in remote hilly areas.

(iii) Opportunistic and inadequate beneficiaries' response. Rural people do not own the scheme and damage the system for their own personal benefits.

(iv) Non-involvement of community/beneficiaries. In the State of Jammu & Kashmir the responsibility of planning, construction, operation and maintenance of rural water supply system solely vests with the respective P.H.E. Department in all the three regions namely Jammu, Kashmir and Ladakh. No local agencies whatsoever e.g., Zila, Block or Village Panchayats are involved in any of the activities related to rural water supply programmes unlike in some other states in the country.

(v) Lack of awareness about the quantity, quality and cost of water supply among the masses.

The public have no regard for judicious usage of water.

(vi) Unskilled Operational Staff.

A sizeable number has been engaged on daily wage basis, most of whom do not have sufficient training, experience and skill in their trade and are not serious about their duties.

(vii) Trade Unionism.

Operational staff resorts to agitational approach on the slightest pretext.

I have endeavoured to put forth the problems countenanced in the field by Water Supply Engineers in a free, frank and forthright manner. It is quite likely that such problems are also being faced by fellow-engineers elsewhere in the country. Nevertheless, it is considered imperative that the issue is deliberated upon in a pragmatic manner and remedial measures suggested to make the operation of Rural Water Supply Schemes in the hilly areas of our country more effective and efficient.

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Water-treatment to Produce Potable Water for Rural Communities of Chitrakut Region

G. K. Kannan* and Sadhana Chaurasia*

1. Introduction :

Chitrakut region of Bundelkhand has many villages, some lying in Madhya Pradesh and some in Uttar Pradesh. The topography of the area is rocky and undulating terrain. The only perennial surface-water stream is river Paisuni, which has an average flow of 1.5 to 2.0 m^3/sec during fair weather periods. The rural populace in the area tediously taps the scanty cavernous groundwater for various domestic and irrigational purposes. Table 1 presents information pertaining to water resources available in some typical villages in the area. The water table in the wells lowers to around 50 ft below ground level and most of the shallow wells become dry during summer months. This leads to acute water scarcity during summer months and forces people to somehow fetch whatever quality of water may be available, often from far off places. The well and hand pump water is often bacterially contaminated and is apprehended to cause various water-borne diseases. This is substantiated from the bacteriological data furnished in Table 2. From the table it becomes obvious that even handpump water is not safe for drinking without disinfection. Deep tube wells which are considered to yield safe potable water, are successful only along the banks of river Paisuni. Hence, for provision of potable water supply en-masse to rural communities of the region, it

TABLE 2

Coliforms organisms (MPN/100ml) in drinking water of some typical villages in Chitrakut area

Sl. No.	Name of the village	Hand pump	Well
1.	Nayagaon	9	17–1600
2.	Pathara	50	200
3.	Paldev	40	290
4.	Lalapur	50–90	130–170
5.	Sejwar	Below 1	948–5715
6.	Narayanpur	70–80	350–450
7.	Ranipur Bhatt	131	598
8.	Capsethi	50–60	900
9.	Chitra Gokulpur	9	140
10.	Purwa Tarunha	70–80	333–400
Drinking water standard in India — 1/100ml			

TABLE 1

Water resources availability in some typical villages of Chitrakut area

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HARDWAR

Sl. No.	Name of the village	Population (1991)	Number of wells	Water Table in wells from GL (ft)	Number of Hand pumps	Number of ponds	River
	MADHYA PRADESH						
1.	Nayagaon**	2080	6	52	3	—	Paisuni
2.	Pathara	992	5	35	5	1	—
3.	Paldev	2419	8	35	7	—	—
4.	Lalapur	723	15	40	15	—	Godavari
5.	Sejwar	947	2	65	4	—	—
	UTTAR PRADESH						
6.	Narayanpur	630	12	50	8	3	—
7.	Ranipur Bhatt**	1282	3	65	5	1	—
8.	Capsethi	1263	7	50	12	—	Paisuni
9.	Chitra Gokulpur**	1293	8	45	5	—	—
10.	Purwa Taraunha	2500	25	50	12	—	Paisuni

** Community water supply available.

---

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TABLE 3

Water Quality of river Paisuni at different locations (1993-95)

Sl. No.	Name of the location	Critical parameters			Non-critical parameters					
		Turbidity NTU	TSS mg/l	Total coliforms MPH/100/ml	pH	TDS mg/l	Total Hardness mg/l	Cl^- mg/l	So_4^{--} mg/l	Fe^{++} mg/l
1.	Sphatikshilla	8	129	220-340	8.10	316	241	12.6	5.5	0.66
2.	Jankikund	8	135	250-368	8.10	327	238	14.5	8.7	0.77
3.	Pramodvan	7	134	350-370	8.12	328	236	14.7	9.2	0.79
4.	Ramghat	6	149	220-2400	7.96	324	237	15.9	11.3	0.87
5.	Karwi	10	127	11-900	8.22	292	123	17.6	13.6	0.91

was necessary to draw water from surface water sources, such as river Paisuni and supply such water through pipelines after treatment. With this thought three water treatment plants were established in the region as given below:

(i) *Pindra water works:* This presently supplies 0.31 MLD of water to Pindra-Majhgawan belt

(ii) *Sirsavan water supply:* This supplies 0.55 MLD during normal days which is increased mani fold during Mela days. This covers Khohi, Kamta, Nayagaon, Pramodvan, Jankikund and Sirsavan.

(iii) *Patha water supply, Karwi:* This supplies 9.60 MLD water to 146 villages extending to as far as 50 kms away. This plant is considered to be the largest rural water supply scheme in Asia.

The present paper examines the working and performance of two of these water-treatment plants, viz the Sirsavan and the Karwi water-treatment plants to propose appropriate approach for future rural water-supply schemes in the area.

2. Water quality of river Paisuni:

For drinking and other domestic uses, bacteriological and aesthetic quality of the water supply, respectively represented by coliforms counts and turbidity of the water become the most important quality parameters. The values of these parameters (as also other usually considered water quality parameters) monitored at various locations of river Paisuni during non-monsoon periods in 1993-95 are given in Table 3. The results reveal that the river water can not be used for community water supplies without prior treatment as the MPN values are significantly high and even turbidities greater than the 5 NTU permissible under water quality standards prescribed in India. This quality further deteriorates during Mela days, and on the slightest rainfall washing off soil and organic matter into the river.

3. Water treatment processes available for treating Paisuni water:

During non-monsoon periods the turbidity in the river generally remains below 20 NTU and hence river water can be directly fed to sand filters. However, during monsoon season and/or after slightest of rainfall, the river-water becomes highly turbid and requires coagulation, flocculation and settling before being fed on sand filters. For filtration, two types of processes are available:

(i) *Rapid Sand Filters (RSF):* This has been adopted at Karwi water works.

(ii) *Slow Sand Filters (SSF):* This has been adopted at Sirsavan water works and Pindra water works.

After sand filtration the water is chlorinated to make it bacteriologically safe. Essentially sand filters are the main treatment unit and it is necessary to improve the performance of filters by taking proper operational measures.

4. Field study of Karwi water works and Sirsavan water works as typical of RSF and SSF in Chitrakut Region:

4.1 *Karwi water works:*

4.1.1 *Brief description of units:*

The flow diagram of process of Karwi water treatment plant is shown in Figure 1. The dimensions and no. of units in process are as given here:

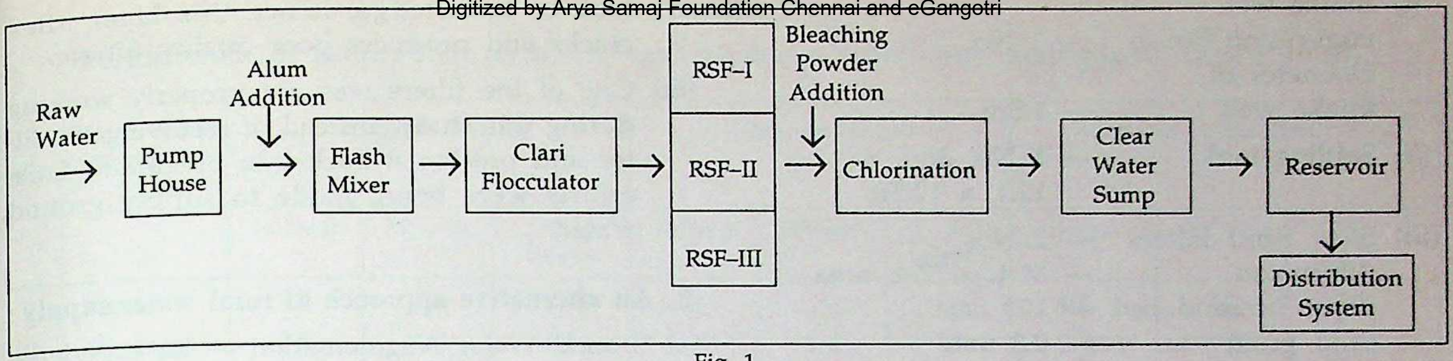
Raw Water
Pump House
Alum Addition
Flash Mixer
Clari Flocculator
RSF–I
RSF–II
RSF–III
Bleaching Powder Addition
Chlorination
Clear Water Sump
Reservoir
Distribution System

Fig. 1
Flow diagram of Karwi water treatment plant

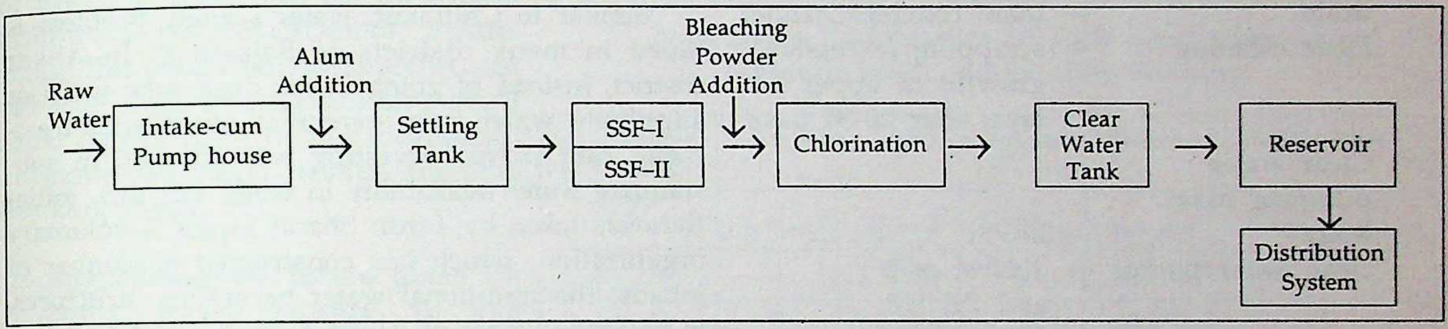
Raw Water
Intake-cum Pump house
Alum Addition
Settling Tank
SSF–I
SSF–II
Bleaching Powder Addition
Chlorination
Clear Water Tank
Reservoir
Distribution System

Fig. 2
Flow diagram of Sirsavan water treatment plant

(i) Flash mixer — 1 No. 3.4m x 1.37m

(ii) Clariflocculator

(a) Flocculator — 1 No.
dimension — 6.10m dia. x 4.9m depth
detention time — 30 minutes

(b) Clarifier — 1 No.
dimension — 19m dia. x 3.9m depth
detention time — 2 hr.

(iii) Rapid Sand Filters — 3 Nos. 5m x 4m area each
Sand-grain size — 0.35 to 0.65 mm
Bed thickness — 62.5 cms.
Filtration rate — 8.75 m/hr.

(iv) Back-wash water tank — 70m^3
Backwashing — After 20-30 days.

(v) Clear water sump — 100 m^3

4.1.2 *Performance of Rapid Sand Filters at Karwi Water Works:*

The performance of RSF at Karwi water works is given in table 5. The results indicate that only 58% of turbidity and 85% of suspended solids are removed by RSF. The bacterial removal also was observed to be only 55% and required significant further reduction through disinfection.

4.1.3 *Problems faced in operation at Karwi water works:*

(i) The flow controllers at Karwi water works are out of order and this adversely affects filter performance.

(ii) Coagulation and flocculation are not regularly carried out. This often quickly clogs the filters and necessitates frequent back wash.

(iii) Back wash is not properly carried out. Mud balls remain stuck upon sand, pipes and walls creating trouble in filter operation.

(iv) The Karwi water works does not have any laboratory facility to determine alum dosing, chlorine dosing or residual chlorine. The residual chlorine completely vanishes at far off supply points. Bleaching powder is added on the basis of assumption only.

(v) In this big water supply system, water rarely reaches the tail end villages. The residual chlorine completely vanishes in the tail end. Pipelines are stolen at some places due to lack of frequent supervision. This poses serious maintenance problem.

4.2 *Sirsavan Water Works:*

4.2.1 *Brief description of units:*

The water treatment process of Sirsavan is shown in flow Fig. 2. The units and their operation features are given further:

(i) Intake well cum-pump house — 1 No.
Diameter of intake well — 1.5m
(ii) Settling tank — 1 No. 36ft. x 12ft. x 12.5ft.
(iii) Slow Sand Filters — 2 Nos.
dimension — 61ft. x 35ft. area
depth of sand bed — 120 cms.
sand grain size — 0.3 mm
Filtration rate — 0.17 m/hr.
type of under drain — main concrete channel
Filter cleaning — scrapping (excessive growth) in upper layer after 20-30 days
(iv) Clear water pumping main length — 275 m
clear water pumps — 2 Nos. of 5 and 7.5 HP
(v) Reservoir
Type & location — Stone masonary on the top of nearby hillock
Capacity — 225 m^3

4.2.2 *Performance of Slow Sand Filters at Sirsavan Water Works:*

The performance of SSF is given in Tables 5 and 6. SSF was observed to be effective in removing as much as 80% of Turbidity and Suspended Solids. Besides, it showed good bacterial removal efficiency of 91-95%. This obviously yields a better quality of treated water and requires only nominal disinfection effort. Analysis of Schmutzdecke and sand layer is given in Table No. 4.

4.2.3 *Problems of SSF operation at Sirsavan Water Works:*

(i) In this plant also alum dosing and bleaching powder addition is carried out basically on assumption.

(ii) Schmutzdecke is not properly managed due to lack of knowledge, hence this layer often cracks and produces poor quality filtrate.

(iii) One of the filters was not properly working during this study. Instead of rectifying the filter and putting it back into operation, futile efforts were being made to supply ground water.

5. An alternative approach to rural water supply:

Ground Water Augmentation — an experience in Alwar Region, Rajasthan:

Similar to Chitrakut, water scarcity problem is faced in many districts of Rajasthan. In Alwar district, instead of going in for deep tube wells or supplying water from perennial rivers after treatment, rain water harvesting was adopted to substantiate water availability in wells. For this, initiative was taken by Tarun Bharat Sangh, a voluntary organisation, which has constructed a number of Johads, the traditional water harvesting structures, in various villages of Alwar district. The Johads are designed primarily to collect run-off of small catchments. The collected water percolates into ground and has perceivable impacts as listed below:

(i) Water level in wells increased to 35-50 ft from ground level in villages where Johads have been built while it was more than 75 ft in non Johad conditions. This obviously relieved women from their hardship of fetching potable water from far off places.

(ii) Irrigated land increased 2-3 fold after building Johads compared to pre Johad conditions.

(iii) The enhanced irrigated land increased maize and wheat production by ½ - 2 times in Johad villages.

(iv) The mean value of livestocks per household increased to 10 in Johad villages, where green fodder and water were available for longer periods in an year.

This clearly displays that rain water harvesting is the best means not only to increase availability

TABLE 4

Analysis of Schmutzdecke and Sand Layer of Slow Sand Filter at Sirsavan After 15 Days Operation

Sl. No.	Parameter	Schmutzdecke (Top 3 mm layer)	Sand Layer (Below 3 mm from top)
1.	Algal content (mg/m^2)	1040	—
2.	Standard Plate Count Nos./gm of wet weight	8000-9000	50-60

TABLE 5

Performance of sand filters at Karwi and Sirwavan water treatment plants (April 1995)

Sl.	Name of the Treatment Plant	Turbidity (NTU)			Suspended Solids (mg/l)			Bacteria MPN/100ml		
		Influent	Effluent	% removal	Influent	Effluent	% removal	Influent	Effluent	% removal
1.	Karwi	12	5	58	20	3	85	800	360	55
2.	Sirsavan	2.5	0.5	80	5-10	1-2	80	100-400	9-20	91-95

of drinking water but for an overall upliftment and development of rural areas. This leaves behind apprehension of bacteriological contamination, which could be overcome by pot disinfection or installing hand pumps for safe drinking water.

6. Suggestions for future plans for rural water supply in the Chitrakut Region :

From the above discussion following aspects emerge for optimally operable and economically viable approaches for planning future water supplies in the region.

(i) Priority should be given to harvesting rain water to augment ground water resources in villages, which will make the villages self dependent as visualized by Mahatma Gandhiji. Also even small communities shall be independent and not dependent on piped supplies.

(ii) If this becomes non-feasible, surface water from nearby sources shall be the only alternative. Surface water shall require treatment; for this, one should opt for small treatment plants with distribution systems as small as possible. Large plants like Patha water works should be avoided.

(iii) Among available treatment processes, simpler ones like Slow Sand Filter should be preferred for rural areas.

(iv) The operators should preferably be science graduates with adequate ability to test the chemical and biological quality of water. In all cases operators should be trained for proper maintenance and operation of filters.

TABLE 6

Progressive Performance of slow sand filter of Sirsavan water works after washing

Sl. No.	Number of days after washing	Turbidity (NTU)		Suspended Solids mg/l		MPN/100ml	
		Influent	Effluent	Influent	Effluent	Influent	Effluent
1.	3	3	1.5(50)	40	10(75)	—	—
2.	5	3	1.5(50)	50	10(80)	—	—
3.	7	3	1.2(60)	20	5(75)	100	9(91)
4.	12	2	0.6(70)	15	3(80)	390	20(94)
5.	18	2	0.6(70)	20	3(85)	239	18(93)
6.	20	2	0.5(75)	15	2(87)	363	18(95)

Values in bracket indicate percentage removal.

(v) In case of plants with Slow Sand Filters, since Schmutzdecke is responsible for the performance of slow sand filters, the operators should be made adequately aware of this and be trained to effectively conserve and manage this biological layer.

(vi) If SSF can not be adopted due to larger land requirement in some cases, intermediate rate filters, horizontal filters, MIMO (Multiple Inlet Multiple Outlet) or other types should be considered before directly deciding in favour of RSF.

(vii) There must be regular testing and maintenance of records of performance of individual units. As soon as the effluent quality of a unit becomes poor, one has to take necessary steps to rectify the situation. Going by a set routine in an unscientific manner and bureaucratic callousness in the name of administrative and financial procedures should not be tolerated when serious health considerations like quality of drinking water are involved.

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Integrated Environmental and Sanitary Engineering Project at Mirzapur

Er. Syed MD. Hammad*

Introduction :

Mirzapur Town having a population of 1,30,000 is situated on the right bank of river Ganga midway between Allahabad and Varanasi. The town is spread along river Ganga in a stretch of about 10 Kms. its width varying from 1 Km to 2 Km. Prior to launching of Ganga Action Plan in this town, no sewerage system and other Sanitary facilities existed and all dry weather flow was going to river Ganga through a number of storm water drains. In the year 1987 the Governments of India and the Netherland agreed to a bilateral cooperation in the Environmental and Sanitary Engineering Project for this town as a whole and part of Kanpur city under Ganga Action Plan. The main objective of the project was to implement sanitary Engineering works through an integrated approach for the improvement of sanitary conditions of the town and to reduce pollution load in the River Ganga at the same time. It was also to demonstrate that by using anaerobic waste water treatment processes a substantial part of energy requirements of waste water treatment could be covered by production of biogas. The technical designs in the projects were to be least cost solutions on a need based approach as are being adopted in projects of similar nature in India as well as through introduction of well established technical solutions in this field. Special emphasis was given to improve environmental and living conditions of inhabitants in the project area with special attention to those living in deprived conditions. With these objectives, in all 7 different projects were sanctioned on which work was started in 1988 and all projects were completed upto June 1994.

Scope of Project :

The scope of the integrated development project comprises preparation of plans, designs, tender documents, and implementation within a time bound programme. U.P. Jal Nigam was the implementing agency assisted by Govt. of Netherland through a group of three consulting firms. While framing the project, following major components were considered and included in the scope :

(a) Interception of existing storm water drains presently carrying dry weather flow.

(b) Improvement and expansion of sewerage and storm water drainage system.

(c) Low cost sanitation (both private and public latrines).

(d) Solid waste collection and disposal.

(e) Waste water treatment facility.

(f) Improvement and expansion of water supply facilities.

(g) Public health promotion and community participation in order to ensure that the project interventions in the field of drinking water supply, sanitation and solid waste disposal are beneficial to public health.

(h) Institutional strengthening to ensure an effective operation and maintenance of the new facilities to be installed under this project.

(i) Cost benefit and/or cost effectiveness analysis to ensure financial and economic viability of the project together with affordability analysis in order to assess the scope for cost recovery.

(j) Training programme at community, technical and management levels to improve operation and maintenance skill. Projects from 'a' to 'f' except solid waste were formulated and implemented by U. P. Jal Nigam whereas solid waste collection and disposal was implemented by the city Municipal Board. Other programme from 'g' to 'j' were formulated and implemented by the consultants themselves. The project was a 100% grant in aid from the Govt. of Netherlands.

Design criteria and the works executed :

Although Mirzapur town extends for a length of about 10Km. on the bank of river Ganga, only the central portion is the core area where population density is more due to concentration of commercial activity in this area. Carpet manufacturing is cottage industry of this town. According to population density, central part of the town has been named as core area and the other two ends as non core area for design purposes. With these considerations following projects were framed and executed. The project area is entire Mirzapur town within its municipal limits.

---

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(a) *Sewerage and storm water drainage:*

This project was framed and executed at a cost of Rs.3.324 million to improve existing Khandwa and other storm water drains which are carrying dry weather flow. The design consideration was to intercept dry weather flow to sewage pumping stations and discharge excess flow during rains and storm to river. During dry weather these drains serve as trunk sewer.

(b) *Low cost sanitation:*

Under this project in all 19 nos. public toilets have been constructed at important public places to improve sanitary conditions within the city. In addition to improving sanitary conditions of residents, 2689 pour flush off site individual latrines were also executed in the core area where sewerage system was introduced. In non core area where sewerage system was not provided, a total nos. 3908 individual P.F. latrines have been completed. The works of this project were executed at a total cost of Rs.27.752 million. On site latrines are of two pit system of size 1.10 x 1.10 x 1.10 M for 10 users.

(c) *Wide mesh sewer system in core area:*

Under this project 254 hectare core area of the town has been covered. Two existing storm water drains which are flowing in this area have been intercepted and diverted. This works as trunk sewer during dry weather. Main branch sewers in a length of 7.32 Km. with other appurtenant works like 161 nos. manholes, 365 nos. Gullypits, 1126 nos. house connecting chambers, rehabilitation of 33 Km. Surface drains etc. have been carried out. Total completion cost of these works is Rs.33.995 million. The sewerage system will cope with the combined flow for a design population of 87460.

(d) *Interceptor sewer and pumping stations:*

Under this project a trunk sewer in a length of 3.12 Km. with appurtenant works, like manholes, house connecting chambers and gully pits has been completed. Another five main drains have been intercepted and diverted to the trunk sewer. New branch sewers were also laid and connected to the trunk sewer. One intermediate pumping station having 18 mld peak pumping capacity (average 8.5 mld) has been constructed to pump dry weather flow diverted from Khandwa drain. From this pumping station, the dry weather flow collected is pumped to a place Trimuhani beyond which it flows under gravity through trunk sewer upto main pumping station. Pumping capacity of this station is 32 mld to handle peak flow and 14 mld as average flow. Rising main of prestressed concrete pipe has been laid in a length of 2.5 Km. upto waste water treatment plant. Both Pumping stations have been provided with diesel generating sets to avoid interruption in sewage pumping due to power break down. These works were completed at a total cost of Rs.38.852 million.

(e) *Expansion of drainage system in non core area:*

Under this project 4.14 Km. sewers in the non core area have been laid and connected to main pumping station. Rehabilitation of surface drains in 2.00 Km. length with new storm water drain in length of 2.62 Km. has been completed at a total cost of Rs.37.682 million.

(f) *14 mld Capacity waste water treatment plant:*

At the outset of project formulation it was decided to introduce UASB (up flow anaerobic sludge blanket) waste water treatment plant for the treatment of domestic waste of this city. The design criteria were adopted on the basis of studies made by Netherland Govt. on a pilot plant at CaliColombia. The site of UASB plant is away from populated area. It consists of pretreatment (screen and grit chamber), UASB reactor consisting of two compartments of 7 mld each, a polishing pond through which treated effluent is held for a day before final discharge. Anaerobically digested sludge is pumped on sludge drying beds to be converted into manure cake. Biogas collected from the UASB plant is utilized to run dual fuel generating sets to produce electricity. Total completion cost of this component excluding land cost is Rs.35.827 million.

(g) *Water supply supplements:*

The environmental sanitation programme included rehabilitation and strengthening of water supply system of city which was inadequate. Under water supply component, regeneration of 12 nos. tubewells, addition of 5 new tubewells, construction of one overhead tank, laying of about 15Km. of water supply net work, segregation of zones, leak detection and repair and rehabilitation of about 8000 private connections was undertaken and completed. Part of water supply component was financed by State Govt. as well. The total completion cost of this component is Rs.18.592 million.

Design considerations of UASB reactor:

The principle of UASB reactor is to introduce raw sewage at the bottom evenly distributed over its whole area. After few weeks a blanket of anaerobic activated sludge is maintained. The incoming sewage flows upward and passes through this blanket. On its passage fine suspended particles are filtered and soluble components are absorbed into the biomass. This biomass converts the waste into biogas and some new biomass. The gas leaves the blanket in bubbles and also provides necessary mixing. Gas is collected in the separator in upper region. The sludge settles and water passes upward from the legs of deflectors. Settled sludge is digested in bottom Zone. Fig. 1 presents a typical UASB reactor.

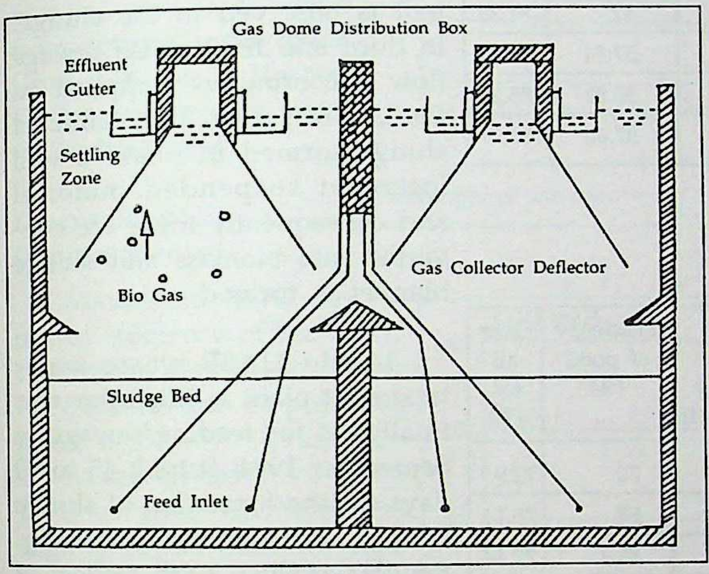

Fig. 1
Typical U.A.S.B. reactor

Waste water characteristics determine the design of the reactor. Design population of 93500 for the year 2006 was adopted. Based on the average flow of 14 mld. two UASB reactors of 7 mld each have been constructed. The other design considerations are given in Table 1.

The plant consists of two coarse screens in parallel, one mechanical and one manual, two grit chambers, with manual mesh screens. The flow to each reactor is regulated through two distribution chambers. There are 128 nos. of inlet feed pipes for each reactor and one inlet point in provided for each 4 Sqm. area of the reactor. The excess and digested sludge from the UASB reactor is withdrawn & dewatered on 8 nos. sludge drying beds of 17 m x 15 m size each on 7 day drying cycle. The biogas is collected in gas holders to run dual fuel generating sets. The excess gas is flared.

Construction aspects:

The reactor tank was built in brick masonry with concrete floor. The walls have rich cement plaster. Deflector beam was built in reinforced concrete. All inner surface was painted with anticorrosive epoxy paint in view of the corrosion effect observed at pilot plant Kanpur. The separators were made from PVC sheets. PVC pipes were used for inlet feed. The weirs, gutters, and gas dome were made from fibre reinforced plastic (FRP) material. Cast Iron pipes were used for sludge withdrawl. Total cost of this plant with post treatment but excluding land cost is Rs.35.827 million (US $ 1.12 millions) and per mld cost works out to Rs. 2.56 millions (US $ 0.8 millions). Per head cost of the plant is Rs.383.00) (US $ 12.0) net average operation and maintenance cost after use of biogas for generating electricity has been found as Rs.1.60 millions per annum (US $ 50,000) of Rs.17 per head per annum (US $ 0.53).

Start up and performance evaluation:

UASB waste water treatment is anaerobic and it does not require seeding for start up. The sewage itself contains all the bacteria and nutrient necessary for the formation of sludge blanket. The

TABLE 1

Design considerations for 14 mld UASB Reactor

UASB	
Peak flow	: 1290 Cum./hr.
Minimum flow	: 408 Cum./Hr.
Average HRT	: 8 hrs.
Minimum HRT	: 3 Hrs.
Size of each reactor	: 28.8m x 16.65m x 5.03m
Volume of reactor	: 2413.67 Cum.
BOD removal expected	: 67.5 %
Maxm COD loading rate	: 1.10 Kg./Cum./day
Polishing pond	
Capacity	: 14 million litres.
Size	: 175.80m x 68.00 (1.19 H.A.)
Depth	: 1.50m. (including 0.25 free board)
BOD loading rate	: 840 Kg./H.A./day
Hydraulic loading rate	: 1.2 Cum/Sqm/day
Detention time	: 24 Hrs.
BOD removal expected	: 50%
Total expected over all BOD removal	: 85%

TABLE 2

BOD Removal

Sl. No.	Month	Flow mld (av)	BOD Inlet mg/l	BOD After UASB mg/l	Efficiency of UASB (%)	BOD After Polishing Pond(mg/l)	Efficiency of pond (%)	Over all eff. (%)
1.	Nov. 94	7.8	197	82	58.4	46	44	76.6
2.	Dec. 94	8.52	185	75	59.6	42	44	77.3
3.	Jan. 95	10.06	172.4	67.8	60.6	40	41	76.8
4.	Feb. 95	7.26	176.10	59.5	66.2	35	41	80.0
5.	March 95	9.89	162.80	58.2	64.10	33	43.3	79.7
6.	April 95	11.26	192.00	74.58	61.16	35.8	52	81.35
7.	May 95	10.45	205.66	84.00	59.16	36	57.14	82.50
8.	June 95	10.22	185.18	58.75	68.27	27.36	59.92	85.23
9.	July 95	9.80	239.00	68.40	71.38	29	57.60	87.87

TABLE 3

COD Reduction

Sl. No.	Month	Flow mld (av)	COD Inlet mg/l	COD After UASB mg/l	Efficiency of UASB (%)	COD After Polishing Pond(mg/l)	Efficiency of pond (%)	Over all eff. (%)
1.	Nov. 94	7.8	317	171.80	50.5	85.70	70	72.96
2.	Dec. 94	8.52	339.50	170.65	49.3	84.40	50	75.14
3.	Jan. 95	10.06	370	147.60	59.75	82.00	43.3	77.84
4.	Feb. 95	7.26	330	145.00	56.1	82.00	43.4	75.15
5.	March 95	9.89	549	254.00	54.4	92.00	64	83.24
6.	April. 95	11.26	471.8	203.06	50.96	82.00	59.62	82.63
7.	May 95	10.45	396.00	160.00	59.60	87.00	45.63	78.03
8.	June 95	10.22	388.13	133.10	65.71	75.30	43.42	80.60
9.	July 95	9.80	410.00	139.50	65.98	79.00	43.36	80.73

TABLE 4

TSS Concentration

Sl. No.	Month	Flow mld (av)	TSS Inlet mg/l	TSS After UASB mg/l	Efficiency of UASB (%)	TSS After Polishing Pond(mg/l)	Efficiency of pond (%)	Over all eff. (%)
1.	Nov.94	7.8	311	135.60	56	65.70	70	78.87
2.	Dec.94	8.52	322.80	141.00	50	79.80	50	75.28
3.	Jan.94	10.06	345	137.00	60	77.00	43.3	77.68
4.	Feb.95	7.26	370	148.00	60	78.00	42	78.92
5.	March 95	9.89	417	132.00	68	57.00	57	86.33
6.	April 95	11.26	442.90	144.57	67.36	39.71	72.53	91.03
7.	May 95	10.45	317.50	97.50	69.29	28.00	71.28	91.18
8.	June 95	10.22	317.60	76.66	75.86	36.00	53.03	88.66
9.	July 95	9.80	417.00	98.00	76.50	45.00	54.08	89.21

biological actions are accomplished in three phases. In first phase accumulation of seeding material from sewage takes place which requires 2 to 4 weeks uninterrupted flow of sewage in the reactor. In the second phase flow of sewage is stopped for two weeks to enable methane bacteria grow on organic matter and convert it into biogas. This phase ends when maximum (nearly 70%) ash content is observed in the sludge. In third and final phase sewage flow is continuously applied on the UASB reactor. The stabilized sludge formed in phase 2 will intercept suspended material and consequently these are converted into biomass and sludge blanket is formed.

14 mld UASB waste water treatment plant at Mirzapur was finally set for feeding sewage in September 1994. It took 45 to 50 days for the formation of sludge blanket without any seeding. Regular analysis with respect to different parameters is being carried out at the laboratory set up with the plant. BOD, COD and TSS reduction at various stage in the plant from November 1994 to July 1995 has been summarised in Tables 2, 3 & 4. Its graphical presentations are shown in Figs. 2, 3 & 4 respectively.

Throughout these months sludge washout was observed from the reactor during peak flow hours. This might have been on account of two reasons. One may be due to inadequate withdrawl of digested sludge from the bottom Zone. The second reason may be disturbance of sludge blanket during peak flow hours. When regulated withdrawl of digested sludge did not reduce sludge wash out, a study was made to observe effect of flow variation of TS concentration in the blanket zone. The results are summarised in Table 5 which indicates that blanket is disturbed during peak flow, consequently reducing the efficiency and sludge wash out. It was also observed that height of sludge blanket varies from 1.6 M to 3.6 M from bottom at different flow rates. The blanket rose upto 3.6M from bottom during peak flow which indicated sludge wash out at maximum flow rate.

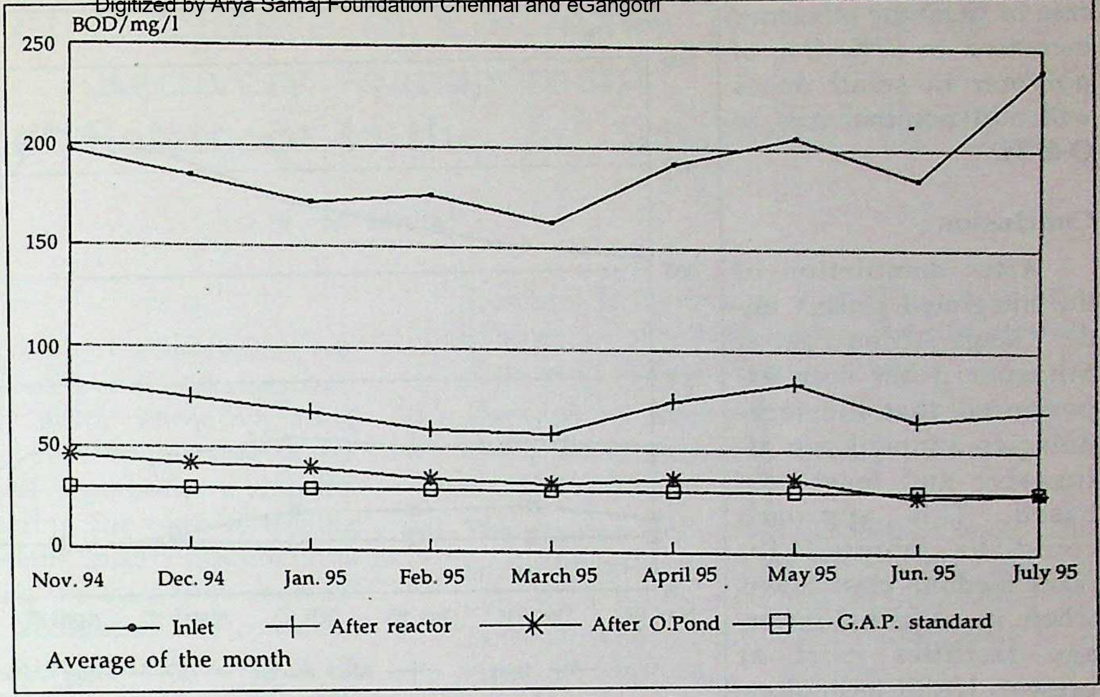

Fig. 2: BOD Removal

Discussions & Improvements :

Maximum BOD removal efficiency of the UASB reactor achieved so far is 71.38% and that of polishing pond is 57.60%. Even with an overall efficiency of 82.5% BOD of final effluent was slightly higher than the regulatory limit of 30 mg/lit. However when overall efficiency rose to 85.23% and 87.87% respectively during June 1995 and July 1995, the BOD of final effluent came below the regulatory limit. Similarly TSS removal efficiency (maximum) of the reactor was 89.21% and that of polishing pond as 72.53%. The overall efficiency varies from 75 to 91%. However at overall efficiency less than 86%, the required regulatory parameter of 50mg/lit. was not achieved. The polishing pond constantly gave odour in the beginning and did not show sign of algae growth. Dissolved oxygen was always absent. In order to improve efficiency of oxidation in (Polishing) pond it was thought to coagulate water after reactor but before entering oxidation pond. A trial was made from 17th April to 27 April 1995 and a polymer namely setlyte 114(A) & (B) was used with a very small dose. These polymers are being manufactured by Kaushal Aromatic Chemicals Pvt. Ltd., Nagpur (India). After laboratory experiment, dose of setlyte 114(A) was fixed at 0.75 to 1.0 ppm and that of 114(B) from 0.04 to 0.05 ppm. These applications showed a tremendous improvement in the polishing pond efficiency. The odour vanished and dissolved oxygen in the pond increased. The pond water became transparent which facilitated development of aerobic state in the pond leading to better performance and elimination of odour nuisance. Efficiency of polishing pond with respect to BOD removal increased to 80% and for TSS 90% and in

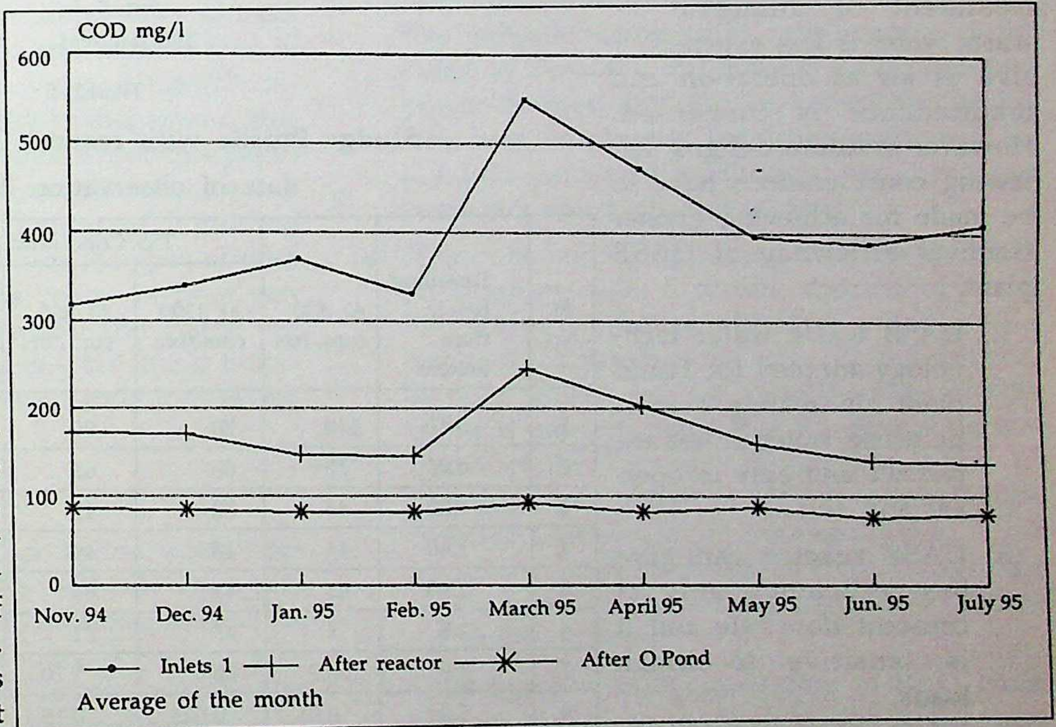

Fig. 3
COD reduction

case of COD the efficiency increased to 87%. Use of polymer in small doses will add nominal cost to O & M.

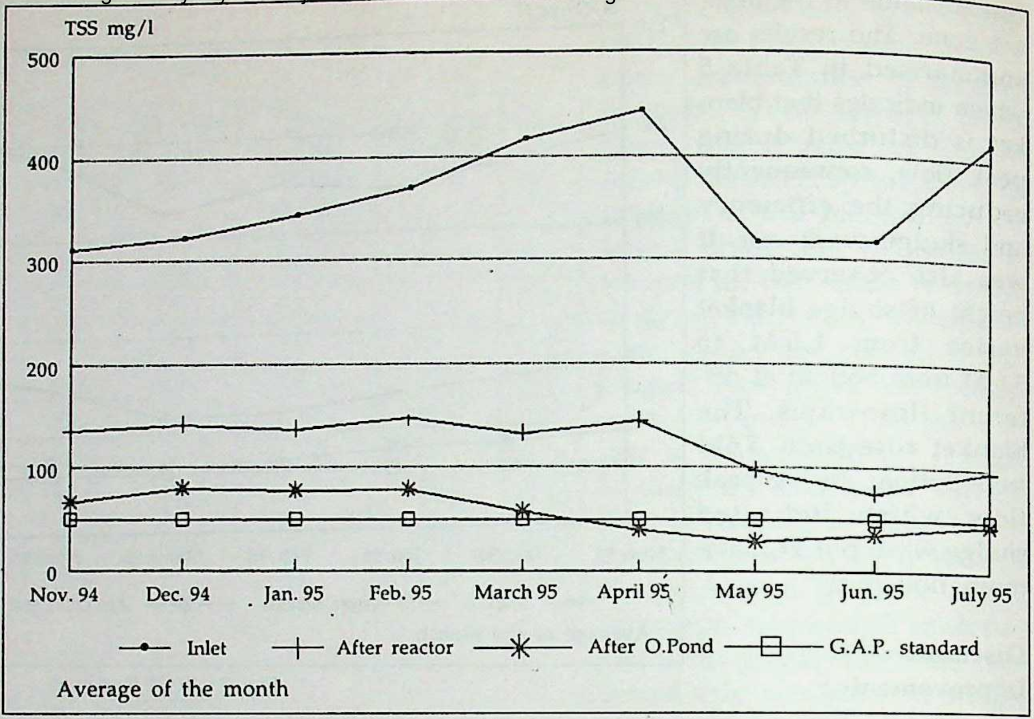

Fig. 4

TSS removal

TABLE 5

Sludge Profile with respect to flow variation

date of observation 26-3-1995

Sl. No.	Sampling height from bottom	At 430 cum/hrs	TSS Concentration g/l VS Concentration g/l					
			At 1290 cum/hrs	At 860 cum/hrs	At no flow	430	1290	860
1.	0.40	110	70	90	120	33	21	27
2.	0.80	70	60	66	80	21	18	20
3.	1.20	45	50	45	47	14.5	16.10	13.5
4.	1.60	44	48	44	46	14.0	15.90	13.8
5.	2.00	43	47	44	45	13.9	15.4	13.2
6.	2.8	8	45	22	0.90	3.0	15.0	7.4
7.	3.6	0.9	25	1.20	0.20	0.3	0.32	0.42
8.	5.0	0.01	0.025	0.15		0.04	0.044	0.045

Conclusion :

After completion of the integrated project under Ganga Action Plan at Mirzapur it has been experienced that the technologies adopted are affordable and least cost based. This approach could be adopted for other medium class towns where no or partial sewerage facilities exist at present. UASB technology adopted at Mirzapur for treatment of domestic waste water is less expensive as far as operation and maintenance is concerned. However in future designs, following considerations have to be made for achieving greater removal efficiency of UASB plant.

(i) UASB waste water technology adopted for 14mld plant for treating domestic waste water is less expensive and easy to operate and run.

(ii) UASB reactor can give best efficiency only at constant flow rate and it is sensitive to shock loads.

(iii) Polishing pond for post treatment is ideal where land is available. It is less sensitive to shock load. However this works as a settling tank only.

(iv) Use of polymer (Setlyte A & B) in small dose every alternate week will enhance efficiency of polishing pond to achieve required parameters and also eliminate odour problem. The cost involved per month has been estimated as negligible.

(v) Polishing pond could be replaced by a two hours retention time settling tank with the use of polymer. However pilot study is required before implementation.

Acknowledgement :

The author is thankful to the Engineers and Laboratory Chemist of Mirzapur Unit for conducting regular test under my guidance and providing data for this paper. The author is also thankful to M/s. Kaushal Aromatics Pvt. Ltd., Nagpur (India) for conducting full scale test of polishing pond with the Polymer setlyte A & B.

In Search of Excellence in Consumer Receivables Recovery Management — with Special Reference to the *Jal Sansthans* of U.P.*

V. K. Sinha**

Introduction :

Consumer receivables recovery management has been one of the most neglected and least discussed areas of the water supply sector. Those operating this part of the sector appear to perceive water works as mere technological organisations, with the sole responsibility of meeting the ever increasing demand for water. As a result, insufficient attention is being given to recovering the dues from consumers. Functions like billing, accounting and collection of consumer receivables have a direct bearing on the financial performance of a water supply and sewerage undertaking. Timely and adequate generation of revenue is of paramount importance to meet the recurrent costs of operation and maintenance of water supply undertakings. In view of the criticality and importance of recovery management, this article has been written. The objective of this paper is (i) to explore the existing information of consumer receivables recovery management of eight *Jal Sansthans* of U.P. in order to assess the state of their performance, (ii) to analyse the causes of poor performance in recovery management, and (iii) to put forward some modest suggestions for doing things differently to improve the performance of recovery management.

Magnitude of the problem :

The author's vast experience in the water supply sector and occasional talks with the engineers responsible for the recovery of consumer receivables reveal that the problem is assuming a gigantic proportion. Some key recovery performance indicators have been evaluated to study the recovery status of all the *Jal Sansthans*. Comparative performance of recovery of dues is presented (Table 1) in a tabular form for easier comprehension.

Observations :

It is evident from the table that :

(i) The generation of revenue in all the *Jal Sansthans* is inadequate and it is not possible to meet the annual operation and maintenance costs with self-generated revenue.

(ii) The working results of F.Y. 1993-94 reveal that nearly Rs.41 crore are stuck in arrears in all the *Jal Sansthans.*

(iii) The revenue collection percentage among all *Jal Sansthans* varies from 25% to 70%. The best collection performance is of Allahabad *Jal Sansthan* whereas the worst performance is of Agra *Jal Sansthan.*

(iv) The cost recovery percentage among all *Jal Sansthans* varies from 53% to 96%. At a glance, this indicator seems to be very impressive for every *Jal Sansthan.* But there is a catch; annual power charges, debt service, contractors liabilities, and employees liabilities such as P.F., G.L.I.C., pension contribution, etc., have not been accounted on accrual basis.

(v) It is quite surprising to note that the Garhwal *Jal Sansthan* raises a current demand of about Rs.2.22 per kilolitre of water whereas the Varanasi *Jal Sansthan* raises a current demand of only Rs.0.26 for the same quantity of water. It is most probable that the dismal performance of the Varanasi *Jal Sansthan* is due to very high percentage of U.F.W. factor. (Unaccounted for water). Among 'Kaval' *Jal Sansthans*, the performance of Agra *Jal Sansthan* seems to be comparatively better than others on this parameter.

(vi) Unrecoverable dues amounting to Rs.41 crore are equivalent to more than one year's revenues (Rs.39 crore) of the *Jal Sansthans.*

Relevant information about the *Jal Sansthans* :

All the water supply and sewerage schemes in the state of Uttar Pradesh are constructed by the U.P. Jal Nigam. After completion of the schemes, these are either handed over to various local bodies or to the *Jal Sansthans* for operation and maintenance. The U.P. government constituted three regional water boards, namely, Garhwal *Jal Sansthan*, Kumaon *Jal Sansthan* and Jhansi *Jal Sansthan* on 2-10-1975 by its Act No. 42 of 1975 for the operation and maintenance of water supply and sewerage services in the hilly region and the Bundelkhan region of U.P. Later on, with the same objective, *Jal Sansthans* were also constituted in five metropolitan cities of U.P. in the year 1978. These are Kanpur, Agra, Allahabad, Varanasi and Lucknow.

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* The views expressed in this article are personal opinions of the author and are in no sense official.

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The commissioner of the concerned administrative division is the chairman of the board of directors of the regional water boards whereas the 'mayor' of the concerned metropolitan town is the Chairman in case of the other *Jal Sansthans*. Every *Jal Sansthan* is headed by a General Manager, who is the chief executive of the *Jal Sansthan*.

Impact of poor performance in recovery management :

It is a well-known fact that in nearly all the *Jal Sansthans* statutory liabilities such as the provident fund, leave encashment, and group insurance premiums, are not being cleared by the respective *Jal Sansthan* for last so many years. The per capita availability of water and the duration of water supply are decreasing day by day. Inadequacy of self generated revenue and consequently failure to service the debt has caused a major blow to the future credits from external agencies. Furthermore, the Government of U.P. has to make substantial annual budget provision for the payment of the electricity consumed by various *Jal Sansthans*. Thus development funds are to be diverted by the government for non-developmental uses.

The basic concept of maintenance viz. 'A stitch in time saves nine' has no relevance in the *Jal Sansthans* because in most of the *Jal Sansthans* only break-down maintenance is being carried out owing to the shortage of funds.

Causes of poor performance in recovery management :

The analysis of Table 1 is quite disappointing for the planners and administrators of the water supply sector. Some of the causes of the poor performance in the recovery management are listed below :

(1) *Lack of performance measurement :*

It is a well-known fact that organisations that measure the results of their work — even if they do not link funding or rewards to those results, find that the information transforms them. This equally holds good for the *Jal Sansthans*. However, it is amazing that so far, there is no state level organisation to evaluate the financial performance of *Jal Sansthans* on a regular basis. Furthermore, performance indicators have not been designed and standardised throughout the state for water supply maintenance organisations.

(2) *Lack of promptness in preparation and distribution of bills :*

The billing section of a *Jal Sansthan* plays an important role in the generation of timely and adequate revenue. This is the foundation on which all the subsequent activities of consumer receivables recovery management are based. The billing section prefers bills for all heads of revenue such as water tax, sewerage tax, and water charges to consumers. Water Tax, sewerage tax bills are to be sent once a year whereas in case of water charges, consumers are to be billed bi-monthly. It has been observed that in most of the *Jal Sansthans*, the above billing frequency is hardly adhered to.

(3) *Lack of proper accounting of consumer receivables :*

Proper accounting of consumer receivables is a prerequisite for good recovery management. It is a common complaint of the consumers that inspite of making payment, outstandings are shown in their bills. Needless to say, timely posting of receipts and totalling of ledgers serve as great help in providing the necessary feed back to improving and encouraging better performance in recovery management. Proper accounting also aids in separating the payers from non-payers for disconnection of water connections or to adopt coercive measures such as realization of dues as arrears of land revenue. This also helps the top management of the *Jal Sansthan* to know whether the organisation is on the right track. Quite often, bills have to be revised due to wrong meter reading, reduction/increase in assessment of annual value or some clerical error. Usually the revised demand is not communicated to the accounts section. The revision of bill necessitates that reverse entry should be simultaneously passed by the accounts section. Presently, this practice is not prevalent in most of the *Jal Sansthans*. Furthermore, when a cheque is dishonoured, reverse entry has to be passed by the accounts department, but normally it does not happen.

Besides the above deficiencies, it has also been observed that if excess payment has been inadvertently made by some consumer, it is not properly accounted. This means that prior to despatch of subsequent bill, excess paid amount should be deducted from the bill amount. This is not being

TABLE 1

Comparative performance of consumer receivables of Jal Sansthans during the F.Y. 1993-94 (Rs. in lacs)

S.N.	Particulars	Garhwal	Kumaon	Jhansi	Kanpur	Agra	Varanasi	Allahabad	Lucknow	Total
1.	Consumer receivables									
	1.1 Opening arrears	463.40	354.54	210.45	686.41	1003.72	363.44	183.31	297.30	3562.57
	1.2 Current demand	767.47	380.72	434.28	818.55	622.19	213.36	343.03	867.20	4446.80
	1.3 Total receivables	1230.87	735.26	634.73	1504.96	1625.91	576.80	526.34	1164.50	7999.37
2.	Recovery during the year	710.81	313.12	395.48	626.06	417.57	261.83	371.53	799.43	3895.83
3.	Recovery performance in percentage	57.73	43.65	62.30	41.59	25.68	45.28	70.58	68.65	55.99[1]
4.	Closing arrears	520.06	414.31	239.25	878.90	1208.34	314.97	154.81	365.07	4095.71
5.	Actual O & M expenditure	1099.85	582.86	409.05	854.92	672.81	468.58	532.90	1100.02	5720.99
6.	Loss	389.04	269.74	13.57	228.86	255.24	206.75	161.37	300.59	1825.16
7.	Percentage of Closing arrears to total receivable	42.27	56.35	37.70	58.41	74.32	54.72	29.42	31.35	
8.	Design capacity in M.L.D.	94.71	53.38 24 Urban	157.93 24 Urban	304 18 Urban	286	220	200	399	
9.	Cost recovery in percentage	64.62	53.72	96.68	73.23	62.06	55.87	69.71	72.67	
10.	Current revenue demand raised per K. L. (in Rs.)	2.22	1.95	0.736	0.737	0.596	0.265	0.469	0.595	
11.	Revenue collection per K.L. (in Rs.)	2.05	1.60	0.68	0.56	0.40	0.32	0.50	0.54	

(*Source*: Budget Estimates of F.Y. 1995-96), [1] = Weighted average.

done by most of the *Jal Sansthans*.

(4) *Impediments of collection efficiency*:

Two activities must precede collection drive to achieve the optimum collection efficiency. First, bill be timely served to all consumers. Second, the bills be correct. If these two activities have been done properly, only then, the question of collection of dues becomes relevant; otherwise it will be a futile exercise toward better collection efficiency.

Path finding for recovery management of the *Jal Sansthan* — Some reflections:

The day *Jal Sansthans* break even or manage to make a small profit on water supply, the event shall be a cause for celebration for the state government as also for management and workforce of the *Jal Sansthans*. For, ever since the *Jal Sansthans* came into existence, these have struggled through serious financial troubles. The *Jal Sansthans* have not gone out of business or have not been folded up so far simply because these (i) handle a life sustaining social commodity like water, and (ii) have continued to be bailed out of financial problems by the state government with periodic electricity charges grants, loans and money saved through unpaid bills to creditors (staff, private and public). Thus, improvement in collection efficiency has become a much sought goal.

The author is of the view that no intellectual brilliance or extra ordinary capabilities are required to improve the performance of recovery management. It is the author's conviction that it is not much of cash but certain structural, legal and behavioural changes that are needed to turn around most of our *Jal Sansthans*. A few hard solutions are indicated below:

1. *Legislative changes:*

(1) As we know, revision of laws, regulations and policies can be done by U.P. Government only; hence the U.P. Govt. should amend some laws/regulations for better results in collection performance.

2. *Need for change in the perception of the U.P. Govt.:*

At present, the state government perceives that the task performed by the *Jal Sansthans* (operation & maintenance) is less important than construction of schemes and hence, requires less money. Since perceptions determine human actions, the tendency during the last 21 years has been to make substantial budgetary allocations to the U.P. Jal Nigam but only meagre ones to the *Jal Sansthans*. The decision-makers at the government level, therefore, need to re-examine their old assumptions about *Jal Sansthan*'s responsibilities and link their funding decisions accordingly. Quite often once a belief gains a hold, it is rarely questioned by succeeding decision-makers.

3. *Interventions required by the Jal Sansthan's top management:*

Undoubtedly, the magnitude of the problem of speedy recovery of dues has assumed an alarming proportion in almost all the *Jal Sansthans*. A few steps needed to tone up the internal subsystems of the *Jal Sansthans* are listed out here:

3.1 *Need to go back to the basics:*

Undeniably, most of the water supply engineers have forgotten the basics of the water supply management. The author is tempted to reflect that if the water supply engineers get down to applying the basics of water supply management, it can make all the difference in the speedy recovery of consumer receivables.

The most important basic that the water supply engineers must relearn is that it is not merely a profession like any other profession, it is above all a service. The connotation of the term 'service' implies among other things, that a public servant exists primarily for serving the interests of the people. Thus, what we need is the change of attitude.

Experience further tells us that 'Service at door step' will be another welcome step towards the ongoing drive of giving better service to tax-payers/consumers. Now, some *Jal Sansthans* organise collection camps in every mohalla at the fag end of the year to mop up revenues. This system needs to be implemented in every *Jal Sansthan*.

The maintenance of no-water complaints register and the day-to-day monitoring of the redressal of the complaints is another basic concept which needs re-enforcement. 'Instant Action Groups' comprising pipe line fitters and beldars should be formed for attendance to the no-water complaints in odd hours.

3.2 *Need to check the possible causes of pilferage:*

The common accusation charged against nearly all the *Jal Sansthans* is that malpractice and corruption on the part of the *Jal Sansthan* employees are mainly responsible for the poor performance of the recovery management. An iota of truth in this accusation is undeniable. These maladies need to be tackled by strict vigilant supervision by senior officers of the *Jal Sansthans*.

3.3 *Mechanisation:*

The use of computers in billing and accounting consumer receivables has become necessary due to highly unionized workers and consequent delay involved in preparation of bills. Furthermore, the requirement of modern manager to have up-to-date and accurate picture of his organisation all the time has necessitated replacement of manual handling by computers for billing and accounting.

3.4 *Timely availability of bill books, demand and collection registers:*

Timely printing and availability of various forms and ledgers to be used in billing and accounting is a prerequisite for the speedy recovery of consumer receivables. It has been observed that often, bill books and ledgers are not readily available. This aspect needs the serious attention of the top management of the *Jal Sansthan*.

3.5 *Billing to be based on the ABC analysis:*

This analysis implies the scrutiny of demands from the stand-point of sums involved. A small proportion of total clientele is usually accountable for relatively large proportion of the total amount of consumer receivables; just 10-15% of the total clientele is responsible for approximately 60-70% of the total amount of consumer receivables. The basic message is that the vital items are few and the trivials are many. Thus, bills should be first sent to those consumers/taxpayers who matter a lot in terms of payment due from them. The consumers/taxpayers should be arranged in descending order of magnitude in terms of monetary value dues against them.

3.6 *Fixation of target for recovery :*

Planning is a pre-requisite for the speedy recovery of dues and forecasting is an essential aspect of planning. Regression analysis should be applied to estimate the values of recoverable sums in the foreseeable future. Information provided by the regression analysis can be modified by considering the role of those factors which have not been included in the regression analysis. Regression analysis means analysis of backward tendency of recovery of dues.

3.7 *Improvement in the quality of service :*

Many a time, consumer resistance appears in the form of delayed payments or no payments because of the poor quality of water supply/sewerage service rendered. If the service levels of water supply could be improved, there are better chances for speedy recovery of dues. Consumer satisfaction needs to be a necessary concomitant of the collection of dues. Increased consumer satisfaction will lead to increased willingness on the part of consumers to pay their dues in time.

3.8 *Recognition of good paymasters :*

We are aware that certain companies offer additional rebate to those creditors who are good paymasters over a period of time. This concept can also be very well used in the speedy recovery of dues of the *Jal Sansthans*..

The names of good paymasters (excluding government departments) should also be got published in local newspapers. This type of scheme should coexist with a scheme of denouncing chronic defaulters.

3.9 *Catalyzing non-government efforts :*

To reduce establishment costs, it has become imperative to catalyze non-governmental efforts. We are aware that often police department offers suitable rewards to take the help of citizens, especially, where the government employees fail to do a task. This concept is equally good for the *Jal Sansthans*. Detection of illegal connections and installation of Tullu pumps on distribution lines are areas where the rewarding of citizens will go a long way in enhancing the performance of consumer receivables.

3.10 *Use of competition :*

We are aware that competition promotes efficiency and accountability. Competition can be indirectly introduced in the water supply sector to improve operational efficiencies and maintenance level. *Jal Sansthans* can very well use the concept of 'Yardstick' competition. It means that the *Jal Sansthan* should compare performance of recovery management among its various collection units/regions. Needless to say, such comparisons serve as a great help in providing the necessary feed back to improving and encouraging performance. Comparisons will help in finding out the reasons which most positively influence better results so that they could be emphasized to make needed modifications, if any.

3.11 *Inculcating the habit of self-help among taxpayers :*

It is a well-known fact that self-help is the best help. *Jal Sansthans* can make use of this concept by persuading taxpayers to come to *Jal Sansthan* office to collect the water tax/sewer tax bills.

3.12 *Incentives to employees :*

A well designed revenue enhancement action plan coupled with attractive incentives will go a long way in speedy recovery of consumer receivables. However, while designing such a scheme, it will be prudent to take into account the views of all the concerned employees.

3.13 *Contracting out of billing and collection activities :*

The advantages of using computers in billing, accounting and collection of consumer receivables have already been discussed elsewhere in the present article. To derive the benefits of mechanisation, it will be prudent to contract out the billing and accounting of dues to competent and reliable private computer firms. The water meter reading and billing activities can also be very easily contracted out. Contracting-out collection of consumer receivables to private parties will be a draconian step but the harsh reality is that there is no option before the *Jal Sansthans*.

3.14 *Effective monitoring and control of dues :*

Key to speedy recovery of dues lies in the design and development of appropriate performance measures and their evaluation and in installing/implementing an effective system of monitoring and control. The author is of the view that performance measurement of recovery management is essential in order to enforce the accountability of the revenue collection staff. 'When the performance measurement process starts', says Stan Spanbauer, president of fox valley technical college, Wisconsion, 'people immediately begin to think about the goals of the organisation'. The *Jal Sansthans* should constantly try new things, find out what works and what does not and learn from experience. Furthermore, Murply's law states 'If anything can go wrong, it will'. This law is true for every organisation including *Jal Sansthan*.

3.15 *Enhancement of managerial capabilities :*

It is a well-known fact that not too brilliant engineers join the *Jal Sansthans*. Reluctance to join water supply services stems not only from emoluments and career progression opportunities but more so due to outmoded work practices, lack of facilities and equipment necessary for doing a better job and most importantly because of an administration that makes water supply engineers responsible for performing a task but does not give them sufficient authority to do it. If at all the *Jal Sansthans* are to be managed on commercial principles, i.e. less dependence on state government for subsidies and grants, there is an urgent need to update the managerial skills of engineers of the *Jal Sansthans* by giving them considerable doses of theory of management.

Furthermore, water supply engineers often blame the external environment for their dismal performance. 'Many people say that the system does not allow anyone to do what he wants to do. Therefore, nothing much happens in this country. I have never blamed the system', says K. J. Alphons, a senior bureaucrat. 'Instead of blaming the system, if people get down to applying themselves, they can achieve miracles'. In the light of the above observation, it is clear that what we need is change of attitude. Officers with positive orientation can completely revolutionise the dues management.

Summary :

It may be very difficult to introduce the suggested reforms/changes in the existing system. But, it is only the hard way that we can go along. Therefore, the present model of recovery management of consumer receivables in the *Jal Sansthans* of U.P. needs to be changed. It is high time that the water supply managers realise the critical role of recovery management in the very survival of the *Jal Sansthans* and rise to meet the crucial situation. While reforming the *Jal Sansthans* is a necessary condition for recovery management, it is not a sufficient condition to deal with the deeper multidimensional crises of the *Jal Sansthans*.

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References :

1. Public policy issues in the pricing of water in urban areas of less developed countries'. Rubbel Kenneth — First course on management of urban water supply — II.P.A. New Delhi.
2. U.P. Water Supply and Sewerage Act, 1975.
3. 'Reinventing Government'. How the Entrepreneurial spirit is Transforming the Public Sector' David Osborne and Ted Gaebler, Addison-Wesley 1992.
4. 'Billing, accounting and collection of consumer receivables in Garhwal *Jal Sansthan*, Dehradun U.P.' V. K. Sinha — Journal I.W.W.A., July-September, 1992.

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Current Trends in Structural Design of Underground Steel Pipelines

R. A. Altekar*, ME(Civil), MIE, MIWWA

Synopsis:

These design notes give information about current trends in the structural design of underground steel pipelines. Concepts such as rerounding factor, importance of pipe zone material properties and use of Timoshenko & Luscher buckling equations have been highlighted with a design example.

1. **Steel pipes are considered as flexible, with following characteristics :**

- ☐ In absence of lateral support excessive deflections occur.
- ☐ Substantial support is generated from passive resistance of pipe zone fill material.
- ☐ Crushing load is mainly resisted by lateral support.
- ☐ Design strength is determined by buckling stability, but deflection and wall stress or strain must be limited.

2. **Structural loads on pressure pipelines are :**

Primary :

- ☐ Internal Water Pressure
- ☐ External such as backfill over buried pipes
- ☐ Surcharges such as vehicular traffic on backfill surface

Secondary :

Self-weight of pipes and contents, significant in pipes of 300 mm and larger in diameter.

3. **External Loads :**

3.1 The vertical earth pressure due to backfill can be regarded as a product: depth of cover x soil density. This is modified by influence of proximity of boundaries within the soil mass, such as trench sides and by influence of relative stiffness in vertical compressibility of the pipe and surrounding material.

3.2 Trench wall influences are considered for rigid pipe installations. For flexible pipes, total vertical earth pressure is considered, whether the pipes are installed in relatively narrow trenches or under extensive areas of fill.

3.3 The prism load for pipes in trenches is increased or decreased by a factor dependent on pipe to soil stiffness ratio. In most design systems, this factor is taken as unity.

3.4 Surcharge loads can be taken from published tables. The tabulated values which are in terms of load per unit length need to be converted to pressure by dividing the load per unit length by the outside diameter of the pipe.

4. **Internal Pressure :**

4.1 Behavior of pipes under external loads is modified due to internal pressure. When internal pressure is applied to a flexible pipe which has deformed under external loads, circumferential stresses are set up again and combine with tensile bending stresses.

4.2 *Rerounding Factor :*

TABLE 1

Rerounding Factor

Pipeline Working Pressure (Bar)	Rerounding Factor D_R
Up to 3	1.00
4	0.90
6	0.85
8	0.80
10	0.75
12	0.70
15	0.65
20	0.50

Notes : 1. D_R should be taken as 1 if depth of cover exceeds 2.5 m or time between backfilling and initial pressurisation exceeds 1 year

2. 1 bar = 100 kPa = 10^5 N/m^2

4.2.1 The internal pressure reduces the out of circle deformations and tends to reround the deformed pipe. This rerounding reduces bending stresses and strains in the pipe wall. The process of rerounding depends on ratio of internal pressure to external pressure and the amount of time-dependent consolidation that takes place around and above the pipe.

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4.2.2 The beneficial effects of rerounding are greater if the internal pressure is applied soon after backfilling and less if there is a longer delay. Field investigations have shown that internal pressure does not have to be continuously sustained for re-rounding to occur.

5. Time Effects :

5.1 The deformation of buried flexible pipes varies with time due to consolidation and settlement of the soil in which the pipes are buried. This time dependency is accounted for in the design by the application of a 'deflection lag factor' D_L (Table 2), which is applied to the calculated deflection in order to obtain long-term equilibrium deflection.

5.2 In non-pressure pipe design, a value of 1.5 is often recommended for D_L though actual value can lie anywhere between 1.0 and 3.0.

5.3 Upto the first application of pressure, time dependent deflection of flexible pressure pipes is similar to that of non-pressure pipes. Subsequent applications and removals of internal pressure result in corresponding reductions and increases in deflection over relatively small amplitudes with no long-term trends towards increased deflection. Some authorities therefore recommend deflection lag factors less than unity for pressure pipes. The consensus opinion, however, is to adopt a value of unity unless a very long time (more than 1 year) is likely to elapse between backfilling and pressurisation and sometimes to apply a separate rerounding factor (D_R) to take into account first reduction in deflection.

5.4 *Vehicular Surcharges :*

The logic of pipe deflection suggests that deflections due to vehicular surcharges should be completely recovered after the passage of the vehicle. In practice, this is not so. Elastic deformations of pipe and surrounding soil are recovered but plastic deformations of the soil are not. These plastic deformations take the form of vertical settlements. Vehicle loads compact the soil. This causes the whole of the backfill to settle bringing greater load on the pipe and restricting its elastic recovery.

5.5 *Time effects on the design of flexible pipes are covered as follows :*

- traffic loads should be included in the pressure causing deflection
- the deflection lag factor should normally be taken as unity
- if long time (greater than 1 year) is likely to elapse between backfilling and initial pressurisation, a value for deflection lag factor appropriate to the type and degree of compaction should be selected and applied to the calculated backfill deflection but not to the surcharge deflection.
- a value of unity should be taken for rerounding factor unless conditions are favourable to rerounding process, e.g. if depth of cover is less than 2.5 m, if working pressure is medium to high (greater than 3 bar) and if the time to first pressurisation is less than 1 year.

6. Design Procedure :

6.1 *This is trial and error process with following steps :*

6.1.1 Select trial pipe considering required pressure class and stiffness requirement.

6.1.2 Establish design limits — maximum permissible deflection, wall stress and strain.

6.1.3 Establish values for deflection lag factor and rerounding factor.

6.1.4 Select pipe zone fill material and evaluate modulus of passive resistance.

6.1.5 Calculate initial pipe deflection and check against permissible limits.

6.1.6 Calculate long-term pipe deflection and check against permissible limits.

6.2 *Pipe Deflections :*

Pipe deflections are calculated
Iowa-Spangler Equation :

$$\frac{\Delta}{D} = \frac{K(D_L\ Pb+Ps)}{8EI/D^3 + 0.061E'} \times D_R \qquad \dots (1)$$

where,

Δ = Linear deflection of pipe vertical diameter
D = Pipe diameter
D_L = Deflection lag factor
D_R = Rerounding Factor
Pb = Vertical pressure due to backfill
Ps = Vertical pressure due to surcharge loads
EI/D^3 = Pipe stiffness
E^1 = Modulus of passive resistance of pipe zone fill material
K = Bedding constant (0.11 to 0.083)
0.083 where bedding material is gravel
0.100 where bedding material is sand

TABLE 2

Deflection Lag Factor D_L

Pipe zone material	Normal Case	Backfilling to Initial Pressurisation more than 1 year	
Compactions	All	Heavy	Light
Gravel	1.0	1.0	1.25
Sand	1.0	1.25	2.00

Note : Pipe zone materials other than sand and gravel produce D_L value upto 3 or more.

6.3 **Buckling:**

The resistance to buckling can be calculated either with or without assistance of pipe zone fill material. Unless the designer is confident that there is no risk of subsequent adjacent excavations removing the soil support and also that the assumed values of soil modulus will be definitely achieved, the buckling resistance of water mains buried at less than 1.5 m cover depth should be calculated ignoring soil support by using Timoshenko buckling equation :

$$P_{CR} = \frac{24EI/D^3}{(1 - m^2)} \qquad \text{... (2)}$$

where

P_{CR} = Critical external pressure required to cause buckling

EI/D^3 = Pipe stiffness

m = Poisson's ratio (0.3 for steel)

For pipes buried with cover greater than 1.5 m or shallower pipes where soil support can be guaranteed, soil support is taken into account, and critical buckling pressure is calculated using Luscher buckling equation :

$$P_{CR} = (32E^{\prime}\ EI/D^3)^{1/2} \qquad \text{... (3)}$$

Both the checks (2) & (3) should be carried out for pipes laid shallower than 1.5m and should be divided by the value of the external pressure likely to cause buckling. Traffic loadings need not be considered in use of (2). If the result of this division is less than 1, the proposed pipe could be expected to fail by buckling. If the result is greater than 1, it is the factor of safety. Recommended minimum factors of safety are usually between 2 and 4 wherein soil support is taken into account. If Timoshenko equation is used, lower values of factor of safety may be accepted.

6.4 The ring buckling resistance is reduced by any out of roundness of pipe, i.e. degree of deflection reached immediately prior to onset of buckling. The reduction factor to be applied to nominally calculated critical buckling pressure is given by the formulae :

$$D_B = 1 \quad \frac{3\Delta}{D} \qquad \text{... (4)}$$

where

D_B = Buckling pressure reduction factor

$\frac{\Delta}{D}$ = Pipe Deflection

Circumstances inducing buckling are likely to occur after a significant proportion of long-term deflection has taken place. Hence D_B is worked out on long-term deflection. If heavy vehicles are likely to pass over the pipeline prior to pressurisation, the value of deflection to be taken into account should be long-term deflection without application of rerounding factor 'D_R'.

7. Pipe Wall Stress :

Flexible steel pipes, being made from an elastic material could be analysed by stress or strain methods. In practice, bending effects are seldom considered since they are usually small compared with the circumferential stresses at which steel pipes normally operate and are covered by the factors of safety applied to these.

8. Pipe Zone Material Properties :

8.1 In the design of flexible pipes the properties of the pipe zone fill material are of paramount importance for the design of non-pressure pipelines. In pressure pipelines the beneficial effects of internal pressure to some extent reduce the dependence on soil properties.

8.2 The attainment of dense and stiff pipe zone material is important for the following reasons :

- ☐ To limit pipe deflections occurring prior to pressurisation to within allowable levels.
- ☐ To ensure attainment of the required buckling resistance of deep pipelines and to improve the factor of safety against buckling of shallow pipelines.
- ☐ To reduce the reliance on rerounding.

8.3 The pipe zone material property used in flexible pipe design is the modulus of passive resistance E′. The value of this modulus varies for any particular soil, according to the density of the soil and is difficult to measure either in the field or in a laboratory. E′ is also influenced by the presence of ground water, by cohesive effects, by the depth of the fill, etc.

8.4 The tabulated values of E′ are suitable for installations where the width of pipe zone material is sufficiently great for the lateral compressive stress generated by the deflecting pipe to be sufficiently dissipated at the outer edges of pipe zone material to be insignificant. In narrow trenches this may not be achieved. A theoretical procedure developed by Leonhardt gives a correction factor α to be applied to E′.

9. Limitations of Design Methods :

9.1 The discussion of structural design methods for buried pipes has been restricted to the design of cross section of the pipes. In practice, pipelines experience transverse loadings effecting their cross section as well as longitudinal loadings producing beam bending and axial tension and compression. The stresses generated by these longitudinal effects act simultaneously with the transverse stresses acting in the cross sectional plane and should be allowed for specifically in the design or by an adequate factor of satiety in the cross sectional design. For buried pipelines founded on soils, calculations for longitudinal effects are difficult because of possibility of uneven bending reactions developing as a result of poor installation or subsequent ground movement.

9.2 Welded steel pipelines are capable of accommodating high longitudinal stresses in extreme circumstances by going above the design stress, if not the yield stress itself. In these circumstances, the effect on the integrity of coatings and lining and hence on future corrosion resistance needs to be considered.

TABLE 3

Recommended Values of E′

(Depth of Cover 0.9-10m)

Embodiment Description	Material Group Symbol Casagrande	Modulus of Soil Reaction MN/m^2 Degree of Compaction				
		Uncom pacted	80% Mp	85% Mp	90% Mp	95% Mp
Gravel single size	GU	5	7	7	10	14
Gravel graded	GW	3	5	7	10	20
Sand and coarse grained soil with < 12% fines	GP SW SP	1	3	5	7	14
Coarse grained soil with more than 12% fines. Fine grained soil (LL < 50%) with medium to no plasticity and containing more than 25% coarse grained particles	GM GC SM CL, ML mixtures ML/CL & ML/MH	1	3	5	10	
Fine grained soil (LL < 50%) with medium to no plasticity and containing < 25% coarse grained particles	CL, ML mixtures ML/CL CL/CH ML/MH	—	—	1	3	7

Note : Range of E′ values recommended for flexible pipe design are shown with shade.

9.3 Steel pipe diametrical deflections as a function of lining/coating combination is given in Table 5.

TABLE 5

Steel Pipe Diametrical Deflection Limits

Lining	Coating	Recommended maximum diametrical deflection %
Cement Mortar	Cement Mortar	2
Cement Mortar	Flexible coating	3
Flexible linings	Flexible coating	5

Flexible linings and coatings : Bitumen type systems

9.4 Although mortar linings can be regarded as rigid, their corrosion protection performance is not generally impaired by fine cracks, hence steel pipes so lined can accept reasonable deflections. Other types of linings and coatings such as fusion bonded epoxy resins can also be susceptible to strain effects and to cracking.

9.5 Steel Pipes with welded joints can tolerate larger diametrical deflections than pipes with rubber gasketted joints. Suggested limits are given in Table 6.

TABLE 6

Deflection Limits for Joints on Steel Pipelines

Joint Type	Recommended Maximum diametrical deflections percentage
Mechanical/flexible with elastometric gasket	2
Welded	4-5

10. **A design of 700 mm diameter steel pumping main has been given as Annexure to this paper.**

TABLE 4

Comparative Efforts Required to Achieve Recommended E'

Embedment Material			Compacting Details	
Description	Casagrande Group Symbol	Degree of compaction	No. of passes	Thickness of layer in mm maximum
Gravel	GW/GU	80 85 90	1 1 1	450 450 450
Gravel, sand and coarse grained soils with less than 12% fines	GP SW SP	80 85 90	1 1 2	450 300 300
Coarse grained soil with > 12% fines	GM GC SM	85 90	1 2	300 150
Fine grained soil LL < 50% with medium to no plasticity and containing > 25% coarse grained particles	CL ML ML/CL ML/CH	85 90	2 2	300 150

11. **References :**

1. Materials Selection Manual for Sewers, Pumping Mains and Manholes 1993, Water Services Association and Foundation for Water Research.
2. IS: 3589:1991 Seamless or Electrically Welded Steel Pipes for Water, Gas and Sewage (168.3 to 2032 mm O.D.) Specification.
3. AWWA Manual M-11 Steel Pipe. A Guide for Design and Installation 1989.
4. Buried Pipe Design A. P. Moser 1990 McGraw Hill Publishing Co. Ltd.

Annexure

DESIGN EXAMPLE

Data :

Pipe function : Pumping Main
Pipe Material : Steel
Pipe outer diameter : 711 mm
Maximum working pressure : 10 bar
Native soil type : Sand and Coarse grained soil with less than 12 percent fines.
Pipe zone material soil type : Sand compacted to 80% M_p
Depth of Cover : 1.5m

Note : Steel pipes are specified in IS 3589 : 91, Clause 10.1 and Table 3 provide details of outside diameter and minimum thickness. For 711 mm out diameter minimum thickness is 6 mm. For grade Fe 410 steel test pressure is given by $P = \frac{2\,st}{D}$

$$= \frac{2 \times 0.4 \times 410 \times 6}{711}$$

$$= 2.77\ MP_a$$

Pipe Stiffness:

Pipe Stiffness is given by EI/D^3

$$= \frac{2 \times 10^5 \times \frac{1}{12} \times 6^3}{711^3} \times (1000)^2$$

$$= 10016\ N/m^2$$

Deflection

Deflection $\frac{\Delta}{D}$ is given by

$$\frac{\Delta}{D} = \frac{K(D_L\ Pb + Ps)}{8EI/D^3 + 0.061\ E'} \times D_R$$

Where

K = Bedding factor 0.1

Pb = Vertical pressure from backfill
= 29.4kN/m^2
= 29.4 kPa

Ps = Vertical pressure from surcharge
= 6.03 kPa

DR = Rerounding factor = 0.75

EI/D^3 = Pipe stiffness
= 10116N/m^2 = 10.116 kPa

E′ = Pipe zone material soil modulus
= 3 MN/m^2 = 3000 kPa

D_2 = Deflection lag factor
= 1

$$\frac{\Delta}{D} = \frac{0.1(1 \times 29.4 + 6.03)}{8 \times 10.116 + 0.061 \times 3000}$$

= 0.01342 or 1.342 % (No rerounding)

with application of rerounding factor D_R

$$\frac{\Delta}{D} = 0.75 \times 1.342$$

= 1.007%

Acceptable limits for deflection of cement mortar lined pipes is 3%. Hence the design satisfies the deflection criteria.

Assessment of Buckling:

(a) *Using Timoshenko Equation:*

As depth of cover is 1.5 m, no allowance is made for supporting effects of side fill and buckling is accessed using Timoshenko equation.

P_{CR} = Critical external pressure to cause buckling

$$= \frac{24\ EI/D^3}{1 - m^2}$$

$$= \frac{24 \times 10.116}{1 - 0.3^2}$$

= 266.80 kPa

External pressure due to backfill only is 29.4 kPa
Factor of safety against buckling (Timoshenko)

$$= \frac{266.80}{29.4}$$

= 0.07

Hence the design satisfies the buckling criteria.

(b) *Using Luscher equation:*

$$P_{CR} = (32\ E'\ EI/D^3)^{1/2}$$

$$= (35 \times 3000 \times 10.116)^{1/2}$$

= 985.46 kPa

Factor of safety against buckling (Luscher) $= \frac{985.46}{29.4}$

= 33.52

External Pressures including surcharge pressure = 29.4 + 6.03

= 35.43

Factor of safety against buckling (Luscher)

$$= \frac{985.46}{35.43}$$

$= 27.81$

Hence the design satisfies the buckling criteria.

Buckling Stability of the Deflected Pipe:

Ring deflection reduces P_{CR} by the factor DB where

$$D_B = 1 - \frac{3\Delta}{D}$$

Pre-Rerounding $\frac{\Delta}{D} = 1.342$

Post-Rerounding $\frac{\Delta}{D} = 1.007$

$$D_B(\text{Pre-Rerounding}) = 1 - 3 \times \frac{1.342}{100}$$

$$= 0.96$$

$$D_B(\text{Post Rerounding}) = 1 - 3 \times \frac{1.007}{100}$$

$$= 0.97$$

Revised Factor of Safety:

(a) *Timoshenko Method:*

$$P_{CR} = 0.96 \times 266.88 \text{ kPa}$$

$$= 256.128 \text{ kPa}$$

Revised factor of safety

$$= \frac{256.128}{29.4}$$

$$= 8.71$$

(b) *Luscher Method:*

Pre Rerounding

$$P_{CR} = 0.96 \times 985.46$$

$$= 946.04$$

Revised factor of safety

$$= \frac{946.04}{35.43}$$

$$= 26.70$$

Post Rerounding

$$P_{CR} = 0.97 \times 985.46$$

$$= 955.8574$$

Revised factor of safety

$$= \frac{955.8574}{35.43}$$

$$= 26.98$$

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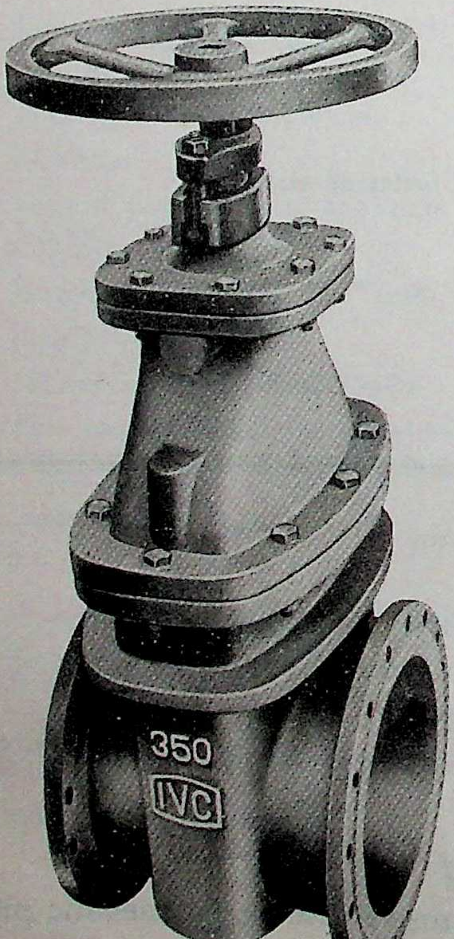

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Short Communications

1

Micro Computer Application : 2

R. A. Alteker*, M.E.(civil), MIE, MIWWA

Information about 18 Microcomputer programs in the book Water and Waste Water Engineering Hydraulics by T. J. Casey is given below :

1. FLUPROPS.BAS

The Program contains an interactively accessible data base of fluid properties. The physical properties of water: density, dynamic viscocity, surface tension and saturation vapour pressure are computed by linear interpolation between relevant tabulated values. Physical properties of gases air, oxygen, nitrogen, methane, carbondioxide at a given temperature, density, dynamic viscocity, specific heat at constant pressure, specific heat at constant volume and specific gas constant are also computed.

2. FRICTF.BAS

The program computes the friction factor f from the supplied input data using laminar flow equation $f = \frac{64}{Re}$ or Colebrooke-White equation for turbulent flow :

$$\frac{1}{\sqrt{f}} = -\,2.0 \log \left(\frac{k}{3.7\ D} + \frac{2.5}{Re\ \sqrt{f}} \right)$$

The program outputs the computed values for the friction factor and Reynolds number.

3. PIPFLO.BAS

The program computes the hydraulic gradient for a specified flow rate or the flow rate for a specified hydraulic gradient. It offers the user a choice of flow formula, Colebrooke-White, Manning or Hazen-Williams. It incorporates FRICTF as a subroutine for computation of the friction factor f, using a fixed value of $1 \times 10^{-6}\ m^2\ s^1$ for kinematic viscosity.

4. SSFLO.BAS

The program computes the head loss associated with steady flow of sludges in pipes including primary, activated, digested and humus sludges. For inputs suspended solids concentration, pipe internal diameter, pipe roughness, and sludge discharge rate, the program outputs hydraulic gradient, Reynolds number and velocity.

5. MANIFLU.BAS

The program computes the flow distribution through a pipe manifold system consisting of a trunk main with laterals on one or both sides, the lateral pipes having uniformly spaced sharp-edged orifices. Colebrook White equation is used for the calculation of distributed head loss.

6. PNA.BAS

The program is a menu driven program for the analysis of steady flow in pipe networks catering for the range of flow controls including multiple reservoir inputs, pumps, pressure reducing valves, and non return valves. It uses the travers algorithm for loop selection and flow initialization; analysis is based on the hardy cross iterative loop flow correction procedure. Menu item 1 NETWORK offers the user choice of flow units l.p.s or m^3s^{-1} and of flow formulae Hazen-Williams or Darcy-Weisbach. It also requests the user to specify the required accuracy of flow computation i.e. the maximum residual integrated loop head loss. Menu items 2-8 are selected for entry/display of network data. These menu items are PIPE, PUMP DEMAND/SUPPLY, VALVE N-R, VALVE P-R, HEAD and ELEVATION. Menu item 9 FILE writes the network data to a disk file on the current drive, thus providing a record for future analysis. Menu item 10 ANALYSIS activates the flow and pressure distribution analysis. The program is coded to run a minimum of 20 iterations. If the specified accuracy is not reached after 20 iterations, computation continues until the required accuracy is achieved. The program output consists of 2 tables presenting flow and pressure distribution; the number of iterations executed to reach the specified error tolerance is also printed.

7. WATHAM.BAS

The program analyses unsteady flow in a pump and rising main system due to sudden cutout. The program is coded to deal with a system bounded by fixed level reservoirs at its upstream and downstream ends. The analysis presumes a non-return valve on the pump delivery. Provision is also made for occasional inclusion of air vessel in the system. It is presumed to be connected to the rising main by a throttle pipe on the downstream side of the non-return valve. The user may analyse the system with the air vessel included or omitted. In absence of air vessel, the analysis assumes that the non-return valve closes simultaneously with the occurrence of 0 forward flow in the rising main. Where the system includes an air vessel the non-return valve is assumed to close simultaneously with the pump cutout and hence the air vessel becomes the effective upstream boundary of the system.

---

* Shah Technical Consultants (P) Ltd., Mumbai-400021.

The program computes the initial steady state flow and, following pump cutout, the variations in pressure and flow at the specified system node points. The maximum and minimum pressure envelopes are also computed.

8. OCSF.BAS

The program computes the unknown flow parameter in steady uniform open channel flow, given the remaining two parameters using the Manning's equation or Darcy-Weisbach equations. The program caters for rectangular, trapezoidal and circular flow sections.

9. HJUMP.BAS

The program computes the incident and sequent depths in hydraulic jumps in rectangular, trapezoidal and circular open channels.

10. GVF.BAS

The program computes the water surface profile from a specified starting depth using a fourth order Runge-Kutta numerical scheme. It caters for rectangular, trapezoidal and circular section channels and following three categories of gradually varied flow :

(i) Computation of water surface profiles in channels without lateral inflow.

(ii) Computation of water surface profiles in collecting channels with a uniform lateral inflow rate.

(iii) Computation of water surface profile and overflow discharge in channels with side weirs.

11. BROAD.BAS

Design of round nosed broad crested weirs.

12. SHARP-1.BAS

Design of rectangular sharp edged weirs.

13. SHARP_2.BAS

Design of v notch weirs

14. SUTRD.BAS

Design of proportional flow weirs

15. FLUME.BAS

Design of long throated flumes

16. OCUSF.BAS

The program computes y and Q in open channel unsteady flow. The program caters for rectangular, trapezoidal and circular channel sections. The computation of friction slope is based on Manning equation. The upstream and downstream boundary conditions included in the program are linear time variations of y and Q.

17. AIRLIFT.BAS

The program computes required air input and required submergence given the pipe diameter, submergence of air injection point, static lift, length of suction pipe upstream of injection point, pipe wall roughness, required pumping rate, liquid density and viscosity.

18. PUMP.BAS

The program computes the coefficients A_1 and A_2 in the rotodynamic pump equation $n = Ao + A_1 Q + A_2 Q^2$ given 3 points on the H/Q standard speed curve including the shutoff head Ao.

References :

Water and Wastewater Engineering Hydraulics, T. J. Casey, Oxford University Press.

ISBN 0 — 19 — 856360 — 4 (hbk)

ISBN 0 — 19 — 856359 — 0 (pbk)

2

Water Quality Index of some Indian rivers

Ram Karan Singh* and **H. Anandh****

Water Quality Indices for some Indian rivers have been worked out based on published data of Central Pollution Control Board, New Delhi, using modified Delphi Method. These are given in table No. 1 below (along with the desired and existing Water Quality levels) and are ranging between 3 to 120.

Table No. 2 on page 254 is giving Primary Water Quality Criteria recommended by Central Water Pollution Control Board in their scheme for zoning and classification of Indian Rivers estuaries and coastal water.

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* Lecturer Civil Engg. Department, B.I.T.S., Pilani (Raj.)

** Undergraduate Student B.I.T.S. Pilani (Raj.)

TABLE 1

Desired and Existing Water Quality Levels

Sr. No.	Portion of River	Water Quality Index	Desired water quality level	Existing Water quality level	Critical parameters
1.	Sabarmati, Dharoidam, Gujarat	33.156	A	Below C	Coliforms, BOD
2.	Sabarmati, Ahmedabad, Gujarat	3.617	E	—	—
3.	Mahi, Sevali, Gujarat	12.88	C	Below C	Coliforms
4.	Mahi, Vasad, Gujarat	12.82	C	Below C	Coliforms
5.	Narmada, Garudeshwar, Gujarat	21.05	A	Below C	Coliforms, BOD
6.	Tapi, Nepa Nagar, MP	31.871	A	C	Coliforms, BOD
7.	Tapi, Burhanpur, MP	28.961	A	C	Coliforms, BOD
8.	Godavari, Ashti, Maharashtra	120.2	C	Below C	Coliforms, BOD
9.	Godavari, Dhalegaon, Maharashtra	12.92	B	C	Coliforms, BOD
10.	Godavari, Mancherial, A.P.	40.35	C	C	—
11.	Godavari, Polavaram, A. P.	35.611	C	C	—
12.	Periyar, Alwaye, Kerala	39.94	E	—	Coliforms
13.	Periyar, Kalady, Kerala	35.682	B	C	Coliforms, pH
14.	Charliyar, Koolimadu, Kerala	38.359	B	C	Coliforms, BOD, DO
15.	Charliyar, Kallapally, Kerala	36.735	B	C	Coliforms, BOD
16.	Subarnarekha, Ranchi, Bihar	12.90	C	Below C	Coliforms
17.	Subarnarekha, Jamshedpur, Bihar	20.349	C	Below C	—
18.	Krishna, Vijayawada, A.P.	13.25	C	—	BOD, Coliforms
19.	Bhima, Takali, Maharashtra	10.09	C	Below C	—
20.	Tungabhadra, Ullanuru, Karnataka	33.33	C	C	—
21.	Penner, Nellore, A.P.	3.55	C	C	BOD
22.	Cauveri, KRS Dam, Karnataka	35.64	C	C	—
23.	Cauveri, Sathyalam, Karnataka	82.878	C	C	—

A	Drinking water and domestic supplies without treatment, but with disinfection.
B	River bathing, swimming and water contact sports
C	Source of raw-water for municipal supplies — consumed only after conventional water treatment
D	Propagation of wild life, animal husbandry and fisheries
E	Agriculture, industrial cooling and washing, hydropower generation and controlled waste disposal

The following is the value of WQI of India

$$WQI = \frac{1}{AR} \sum_{i=1}^{10} A I_{wi} = \frac{1}{23.} \sum_{i=1}^{10} I_{wi} = 24.6{:}62$$

Application in India: WQI of different rivers by different calculations are shown in Table 1. It shows that the Solway weighted method is the best.

WQI 1 = unweighted arithmetic index

$$= \frac{1}{n} \sum_{i=1}^{n} q_i$$

WQI 2 = unweighted Solway index

$$= \frac{1}{100} \left(\frac{1}{n} \sum_{i=1}^{n} q_i\right)^2$$

TABLE 2

Primary Water Quality Criteria

Designated Best Use	Class of Water	Criteria
Drinking water source without Conventional treatment but after disinfection	A	— Total Coliforms organisms MPN/100mL shall be 50 or less. — pH between 6.5 and 8.5 — Dissolved Oxygen gmg/L or more — Biochemical Oxygen Demand 5 days 20°C 2mg/L or less
Outdoor bathing (organised)	B	— Total Coliforms organisms MPN/100mL shall be 500 or less. — pH between 6.5 and 8.5 — Dissolved Oxygen 5mg/L or more — Biochemical Oxygen Demand 5 days 20°C 3mg/L or less
Drinking Water source with conventional treatment followed by disinfection	C	— Total Coliforms organisms MPN/100mL shall be 5000 or less. — pH between 6 and 9 — Dissolved Oxygen 4mg/L or more — Biochemical Oxygen Demand 5 days 20°C 3mg/L or less.
Propagation of Wild Life, Fisheries	D	— pH between 6.5 and 8.5 — Dissolved Oxygen 4 mg/L or more — Free Ammonia (as N) 1.2 mg/L or less
Irrigation, Industrial cooling, Controlled Waste Disposal	E	— pH between 6.0 and 5.89 — Dissolved Oxygen 4mg/L or more — Sodium Absorption Ratio Max 26. — Boron, Max 2mg/L

WQI 3 = unweighted geometric index

$$= \left(\pi_{i=1}^{n} q_i\right)^{1/n}$$

WQI 4 = weighted arithmetic index

$$= \sum_{i=1}^{n} q_i w_i$$

WQI 5 = weighted solway method

$$= \frac{1}{100} \left(\frac{1}{n} \sum_{i=1}^{n} q_i w_i\right)^2$$

The primary water quality objectives for each of the water uses listed above have been defined in the Central Board Publication 'Scheme for Zoning and Classification of Indian Rivers, Estuaries and Coastal Waters (Part One: Sweet Water)'. These quality criteria are given in Table 2.

3

Estimation of Balance of groundwater and utilization for agricultural purposes of Rajampet taluk, Cuddapah district, Andhra Pradesh, India

R. Jagadiswara Rao*, Y. Venkatarami Reddy, G. Sudarsana Raju*****

Introduction :

Rajampet taluk is in the southeastern portion of the Cuddapah district central portion of the Rayalaseema Region, and the southern portion of the Andhra Pradesh State in South India. The taluk has a total geographical area of about 75,866 hectares of which about 83.3 per cent is revenue land and the remaining is the reserved forest land. An assessment of balance of ground water available in the taluk has been done based on an adoption of the procedure devised by the Groundwater Estimation Committee, constituted by the National Bank for Agricultural and Rural Development in Mumbai (NABARD, 1984). It is enumerated below in a Tabular form.

BALANCE OF GROUNDWATER AVAILABLE

A. RECHARGE:

I. *Recharge due to rainfall from land with less than 2° slope:*

(a) Area (Estimated)	55040 hec.
(b) Effective monsoon rainfall (July to December) (Assessed)	770 mm
(c) Infiltration factor (assumed)	20%
(d) Recharge	8476 hec.m

II. *Recharge due to rainfall from land with more than 2° slope:*

(a) Area (Estimated)	20826 hec.
(b) Effective monsoon rainfall (July to December)	770 mm
(c) Infiltration factor (assumed)	5%
(d) Recharge	801 hec. m

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III. *Recharge due to seepage from irrigation water:*

(a) Total irrigated land under paddy (Assessed)	6280 hec.
(b) Water requirement of paddy crop (assumed)	1372 mm
(c) Useful rainfall (50% of the monsoon rainfall)	335 mm
(d) Water applied from tanks, spring channels and wells	1037 mm
(e) Quantum of water applied to paddy crop	6512 hec. m
(f) Seepage factor (assumed)	40%
(g) Recharge	2605 hec. m

IV. *Due to seepage from spring channels:*

(a) Total length of canals	10,200 m
(b) Average wetted perimeter	1 m
(c) Average annual running days	10
(d) Assumed Seepage factor (0.2 m/day)	20 hec.m/day/10^6 m^2
(e) Recharge	20 hec.m

V. *Recharge from seepage from tanks:*

(a) Land occupied by tanks (Assessed)	1,447 hec.
(b) Average land of tanks submerged with water (50% of the area) (assumed).	724 hec.
(c) Seepage factor (assumed)	0.44 m/year
(d) Recharge	319 hec.m

Total Recharge = I + II + III + IV + V = A = 12221 hec.m

---

[*] Professor & Principal, Department of Geology, Sri Venkateswara University, Tirupati-517502.
[**] Lecturer, Department of Applied Geology, S. V. University P. G. Centre, Cuddapah-516003.
[***] Teaching Assistant, Department of Applied Geology, S. V. University P. G. Centre, Cuddapah-516003.

B. DRAFT :

I. *Groundwater draft for irrigation :*

(a) Total Number of existing dug wells, dug-cum-bore wells, bore wells (assessed)	4288
(b) Total Number of pumpsets (assessed)	3765
(c) Draft due to pumpset wells (average discharge of well in year is 0.86 hec.m) (assumed)	3238 hec.m
(d) Total Number of wells where water is lifted by drought force (assessed)	523
(e) Draft due to mhote wells (average discharge of well in year is 0.37 hec.m) (assumed)	194 hec.m
(f) Draft due to irrigation	3432 hec.m

II. *Draft due to population and livestock :*

(a) Population (Assessed)	1,46,872
(b) Draft due to population (2.5 hec.m/1000) (assumed)	375 hec.m
(c) Draft due to livestock (20% of the above) (assumed)	73 hec.m
(d) Draft	440 hec.m
Total Draft I + II = B =	3872 hec.m
Balance of groundwater available for exploitation (A – B) =	8349 hec.m

C. RECHARGE FROM AREA OUTSIDE THE TALUK FROM WHICH RUNOFF PASSES THROUGH THE TALUK :

(a) Area (Assessed)	1089800 hec.
(b) Groundwater balance of the land which passes through the taluk assuming same conditions to prevail as in the taluk (assumed)	100550 hec.m
(c) Quantum of groundwater that could be exploited in the taluk 10% (assumed).	10055 hec.m

Estimated total groundwater balance in the taluk	18404 hec.m
Utilization of the above quantity for Agricultural purpose. Number of conventional irrigation wells required without pumpsets at 0.37 hec.m per well)	49741
or	
Number of conventional irrigation wells required fitted with pumpsets (at 0.86 hec.m/well)	21400
or	
Number of deep tube wells feasible to utilise the balance of groundwater fitted with submersible pumpsets (at 3 hec.m/well)	6135

With the division of irrigated land, the rights over the irrigation well in the land are shared. Very often the wells owned by two or more persons are neglected because of differences among them in the division of their property and there is a tendency on the part of each cultivator to go in for a new well in his land. As a result, some of the high yielding wells owned by two or more cultivators get into disuse and are finally abandoned.

The incentives, subsidies and long-term loans with low interest offered by government make cultivators to go in for the construction of new wells or improve the yield of existing wells.

* * *

SYNOPSES OF PAPERS PUBLISHED IN OTHER TECHNICAL JOURNALS

Evaluation of a simple screening test for faecal pollution in Water

M. A. Grant and C. A. Ziel,
(Hach, 100 Dayton Ave Ames, IA 50010, USA.)

During field investigations in India, Manja *et al.* (7) noted the presence of coliforms in drinking water was associated with hydrogen sulphide-producing micro-organisms. They developed a simple, inexpensive, test to screen drinking water for faecal pollution based on the detection of hydrogen sulphide. Their medium has been subsequently tested and found to be effective by several investigators (8-11); These investigations have been conducted in tropical or sub-tropical regions. Our study examined effectiveness of the medium in samples from a temperate region and emphasised comparison with standard methods for faecal coliforms. We also examined, apparently for the first time, agreement between the hydrogen sulphide method and a test for C. Perfringens. In addition, we tested modifications to the original formulae to compensate for ingredients no longer available and to eliminate the necessity of drying onto paper strips. Agreement between the method of Manja et al. and standard methods for faecal coliforms ranged from 85.7% to 94.4%. Agreement with standard methods for total coliforms ranged from 92.9% to 98.9%. Agreement with methods for C. Perfringens ranged from 71.4% to 80.8%. Our results concur with previous reports that the hydrogen sulphide method of Manja et al. is an effective alternative procedure for monitoring drinking water quality.

(Ref. : Journal of Water Supply Research & Technology, Vol. 45 Number 1, February 1996, Pages 13 & 17)

Experience in coagulant control by use of a charge titration unit

H. Bernhardt and H. Schell, (Wahnbachtalsperrenverband, Siegburg, Germany).

Synopsis :

When treating surface water exposed to rapid and strong quality changes, according to the principle of adsorption coagulation with charge neutralisation, the required coagulant dose is markedly dependent on the content of negative charge carriers (low and high molecular organic acids mineral and organic turbid matter) in the raw water. To determine this negative charge concentration, the raw water must be titrated with cationic polyelectrolytes, or positively charged iron, or aluminium hydroxo complexes. However, the latter approach requires a pH between 6 and 7, which corresponds to the pH range adjusted in the coagulation unit of the water-treatment plant. Since the neutralisation point of the negative charge concentration changes, the charge concentration must be repeatedly determined by titration. It is for this purpose that the Charge Titration Unit (CTU) was designed. As the following article describes, this CTU is capable of computing the coagulant dose faster and more accurately than any manual titration. The dose is automatically determined and transmitted on line from the CTU to the dosing pumps. Even with considerable quality changes in the raw water, this titration unit operates so efficiently that it keeps turbidity, DOC, and SAC 254 in the filtrate at 0.1 NTU, 1-1.5 mg/L and below 2 m^{-1} respectively. But apart from administering the exact coagulant dose, the CTU also has a great ecological advantage over traditional methods. By avoiding overdosing it helps to curb the amount of treatment sludges and consequently reduces landfill costs.

(Ref. : Journal of Water Supply Research & Technology, Vol. 45, Number 1, February 1996, Page 19)

Filter media rehabilitation at a lime-softening plant

James R. Mayhugh Sr., John A. Smith,
Douglas B. Elder, and Gary S. Logsdon.

Water filtration plants treating surface water sources can be expected to routinely produce finished water of excellent quality when the source water quality remains steady or changes slowly. When the quality of the source water changes drastically over short periods, however, treatment plants may face severe challenges. Such a situation occurred at the Decatur, Ill., South Water Treatment Plant early in 1994. After a high-turbidity episode, the lime-softening plant experienced buildup of coagulant and calcium carbonate deposits in the filter beds. The filters and the deposits were evaluated, and an in situ filter media cleaning technique was successfully applied, using glacial acetic acid.

(Ref. : Journal of AWWA, August 1996, Page 64)

Toxicity of chlorine dioxide to adult zebra mussels

Gerald Matisoff, Gary Brooks and
Brent I. Bourland.

Chlorine dioxide (ClO_2) was evaluated as a control agent for adult zebra mussels using single, intermittent, and continuous exposures. A single 30 min exposure to 20 mg/L ClO_2 or higher concentration induced at least 50 percent mortality. NaOCI, $KMnO_4$, and H_2O_2 were ineffective under the same conditions. Intermittent chemical exposure for 30 min each day indicated that ClO_2 at concentrations of 10-20 mg/L can induce significant mortality over three to seven consecutive days (LC50 = 13.0 mg/L), but 1-5 mg/L ClO_2 applied over 28 consecutive daily exposures are ineffective (30 percent mortality). Identical intermittent exposure to NaOCI was ineffective at all tested concentrations up to 30 mg/L. Continuous exposure to ClO_2 for four days was effective at concentrations 0.5 mg/L (LC 50 = 0.35 mg/L0), and 100 percent mortality at ClO_2 concentrations 1 mg/L, was achieved. NaOCI and $KMnO_4$ were less effective. Pooled data yield median lethal dosages at which 50 percent mortality occurred of 14.5 and 82.5 mg h/L for ClO_2 and NaOCI, respectively.

(Ref. : Journal of American Water Works Association, August '96)

FOREIGN NEWS

Saudi Arabia to increase its desalination capacity

Saudi Arabia is considered the world's largest supplier of desalinated water with a total capacity of 520 million gallons of water daily. There are 23 desalination plants located in 15 places; 19 on the Red Sea and four on the Arabian Gulf. These plants supply water to over 40 cities and townships via pipes which cover 2,000 km.

Works on four desalination plants and three water pipeline projects are currently in progress. The addition of these projects will increase Saudi Arabia's desalination capacity to 800 million gallons daily. The plants will also produce 4,500 mW of electricity. The Saline Water Conversion Corporation (SWCC), which supervises the plants, has established a centre for training Saudis on operation and maintenance of the plants. SWCC also works on reducing the production expenditures by conducting research studies at its Research and Development Department in Jubail.

(Ref. : Asian Water & Sewage, June 1996, Vol. 12 No. 5, page 6)

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Waste Water Treatment in Japan

The Japanese Government will spend a staggering ¥ 23.7 trillion (about US $ 284 billion) over the next five years to upgrade the sewerage facilities in the country.

Part of the Government's Eighth Five-Year Sewerage Construction Programme will see the population sewerage coverage increase from 54% (1995) to 66% by the year 2000. Also, more storm sewers will be installed, from 46% to 55% over the same period. Another ambitious project is the employment of advanced sewage treatment process for about 15 million of the population; the present figure is five million.

Of the 940 municipal wastewater plants currently in operation, advanced treatment technology has been implemented in 54 of these. Here, upflow or downflow filtration, coagulation, biological phosphorous removal and biological nitrogen removal are widely used. In addition, ozonation, micro-filtration and ultra-filtration are also implemented in both full-scale and pilot plants for wastewater recycling.

(Ref. : Asian Water & Sewage, June 1996, Vol. 12, No. 5)

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First large-scale UV disinfection system awarded

Trojan Technologies Inc. and its representative Sunwater Ltd. of Droitwich, UK, have received a contract for the first large scale ultraviolet disinfection system in Wales, UK. The contract will supply Welsh Water with a System UV4000 tm to disinfect effluent at the Swansea wastewater treatment plant. The UV system will disinfect to a maximum flow of 1,300 litres/second. Welsh water has recently announced plans to invest an additional $80 million on coastal sewage works over the next 5 years, and a large portion will be spent on disinfection. It plans to fully integrate the UV4000 tm disinfection system into a new wastewater facility producing a very high quality effluent designed to help make the beaches of Swansea and Gower some of the cleanest in Europe, complying with European community's stringent bathing water requirements.

(Ref. : Water & Wastewater International, Vol. 11, Issue 2, April 1996)

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Many of the members of I.W.W.A. have got good useful books on 'Water Supply and Treatment and Disposal of Waste Water' which they may not be requiring now. I.W.W.A. will be pleased to accept such books as donations to their library at Headquarters. Members may please send such books and publications for the benefit of other members of the Association. Such donations of books will be gratefully acknowledged in the Journal of the Association.

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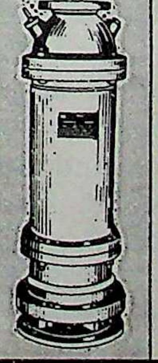

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- Sewarage systems
- Waste Water, Strom Water
- Effluent with slurry and solids

TECHNICAL SPECIFICATIONS

H.P. Range	1.5 to 100 HP
Capacity	upto 750 M³/Hr.
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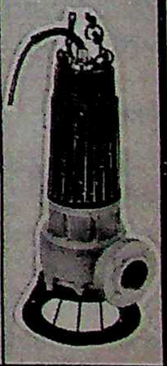

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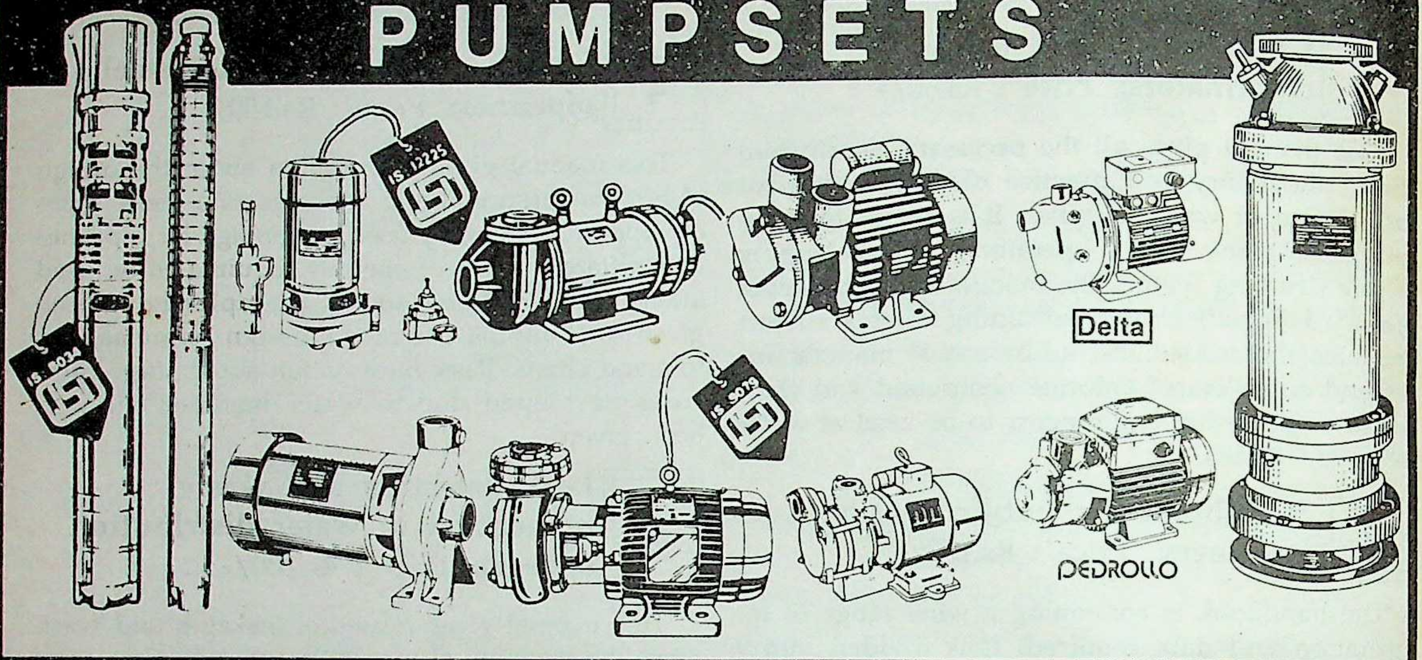

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